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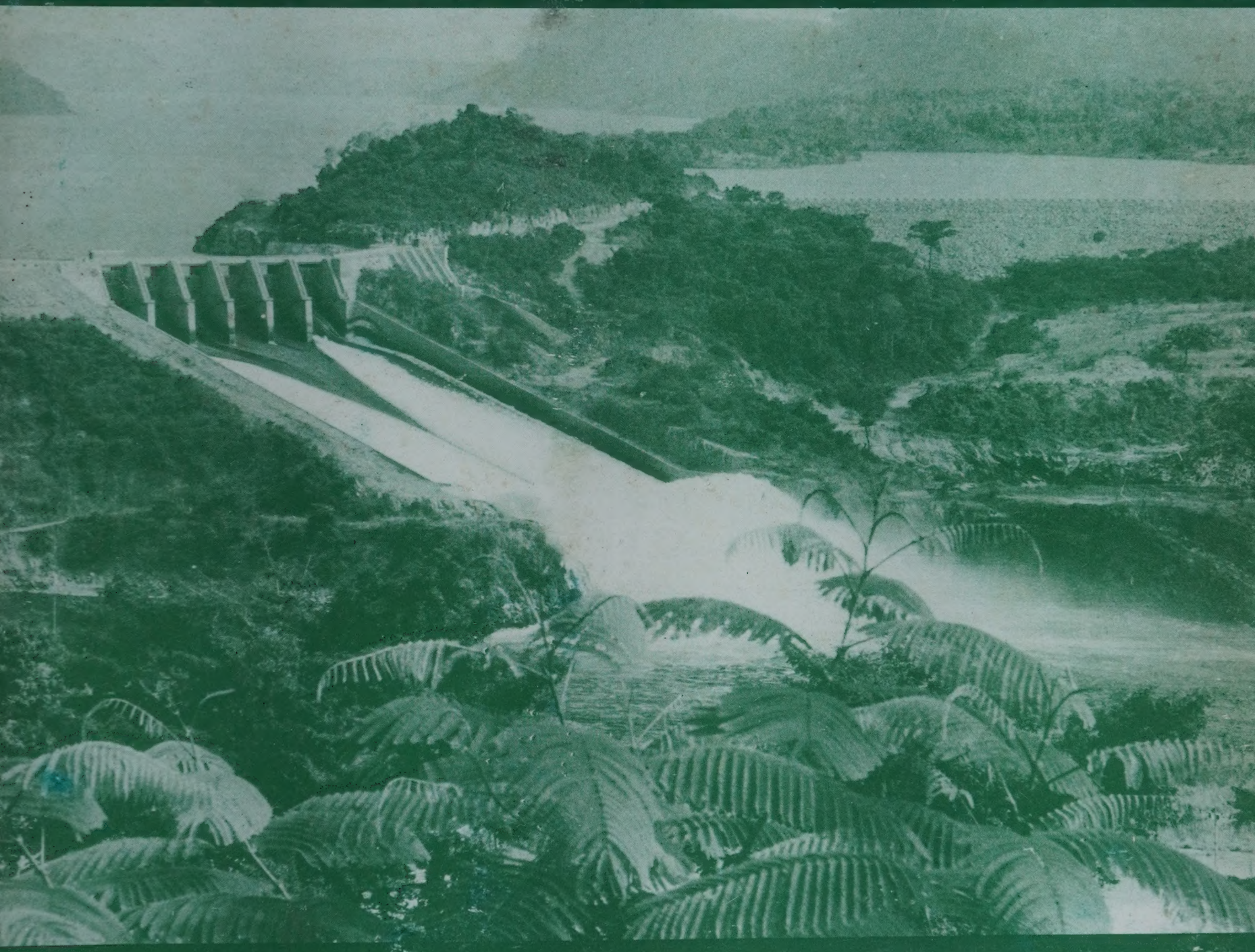

WATER IMPOUNDMENT IN THE TROPICS

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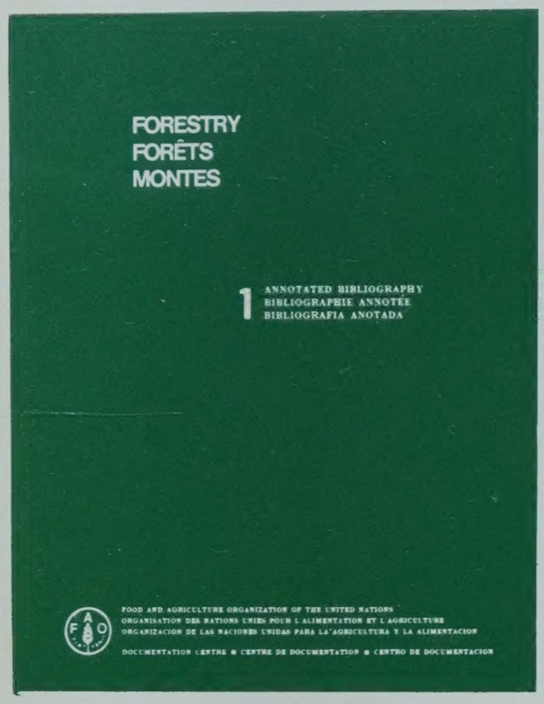
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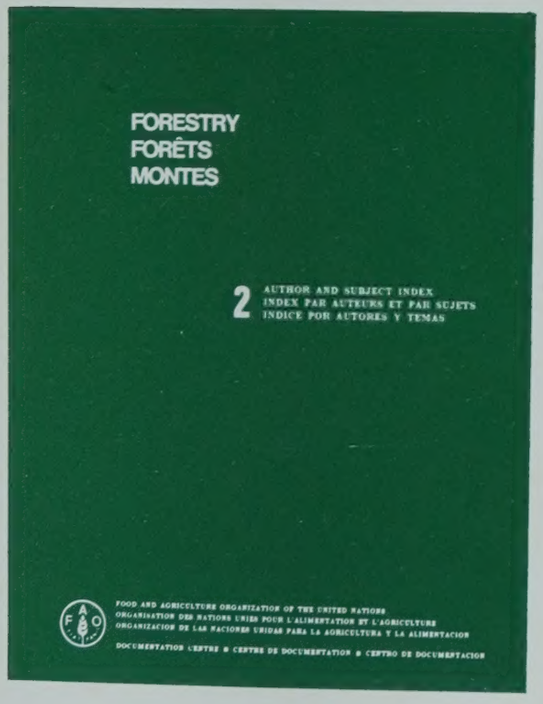
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Ecological aspects of water impoundment in the tropics

What every tropical forester ought to know

Charles R. Goldman

A considerable amount of research has been done on the effects of water impoundment in the tropics. However, despite such research a general lack of knowledge about hydroelectric projects and aquatic biology in the tropics persists.

Studies, by the author and Ecological Research Associates, of the El Cajon Dam site on the Sula river in Honduras (Goldman, 1972a) and the Purari River Project in Papua New Guinea

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(Goldman *et al.*, 1975) are used throughout this article to illustrate many of the principles that should concern ecologists, engineers and governments alike.

Experience with siltation in previous impoundments indicates that it must be considered of major importance to both the longevity and ecology of the reservoir. A detailed study of reservoir longevity as influenced by siltation should, therefore, be a serious concern of any proposed dam construction.

The degree of erosion control in the drainage area of a water-storage project can greatly alter the sedimentation rate. In addition to increasing runoff, the lack of a dense canopy in the watershed surrounding the proposed reservoir or inflowing rivers heightens the impact of rain on soil, allowing soil particle aggregates to be broken down and surface runoff to transport finer particles. The concentration of soil in runoff water is thus increased.

Since certain logging and agricultural practices in tropical countries have greatly increased surface runoff, it is recommended that the watershed be managed with particular attention to soil conservation and forest regeneration. Revegetation and the cessation of human activities which foster erosion can reduce the rate at which the reservoir capacity is decreased by siltation and the reservoir waters are fertilized by materials washed into the system.

Heavy tropical rains, steep valley slopes, and the state of the watershed soils and vegetation all contribute to the rate of siltation. Extreme water turbidity often appears in the tropics during the rainy season.

The potential for slumping of the slopes surrounding a reservoir may also be an important factor as evidenced by the disastrous flood at Lungarone in northern Italy some years ago resulting from a massive landslide into a reservoir. Mass wasting following lumbering was responsible for the death of thousands during a hurricane several years ago in Honduras. But a previous hurricane, although of a greater force, was not as destructive because the root structure of the forest remained intact. Subsequent decay set the stage for the disaster of the next hurricane.

While a reservoir is filling and after filling is completed, it is possible to establish sampling procedures that can provide fairly accurate siltation estimates. In order to obtain these estimates major inflows near their point of entry into the future reservoir must be sampled for settleable materials during the entire year.

Determination of reservoir lifetime is essential in evaluating the true economic potential of the project and

THE SULA RIVER AT EL CAJON, HONDURAS

where shifting agriculture removes topsoil and results in flood control problems

its multi-use aspects. A detailed sampling programme, therefore, must be initiated prior to dam construction in order to realistically predict the expected life of the impoundment.

Large-scale siltation can have pronounced effects on the reservoir biota and its distribution. Turbidity caused by suspended silt can significantly reduce photosynthesis in rivers and reservoirs. This photosynthetic reduction has widespread effects on higher trophic levels of the food chain.

Scanning electron microscopy (SEM) dramatically illustrates the importance of organic and inorganic particles as substrata for aquatic bacteria (Paerl and Goldman, 1972a). The surface area present on particulate matter provides a site for the attachment of bacteria as well as organics and inorganics which adsorb to these surfaces. Thus, by providing surface area for attachment as well as nutrition, silts are able to stimulate aquatic bacterial growth (Paerl and Goldman, 1972b). In addition to providing food for filter feeders, there is good evidence that bacteria and adsorbed organic material may serve as energy for mud-feeding fish.

Although drawdown with exposure of shallow breeding and food-producing areas is probably the most serious threat of water impoundment to fish, sedimentation can also destroy potential spawning beds in the shallow littoral zone of the reservoir. Other aspects of silt deposition include: (*a*) entrapment of these sediments behind the dam, with resulting loss of nutrient sources to downstream agriculture and marine fisheries, (*b*) changes in coastal beach erosion rates, and (*c*) the reduction in deltas which formerly had been replenished by sediment recharge during annual floods. Reservoirs invariably affect the pattern of downstream sediment deposition, and this aspect of any water impoundment in the tropics should receive special consideration in the planning stages.

Water quality following the closing of a dam typically undergoes a transitional period of high organic and inorganic ion concentrations and low oxygen content. The length of the transitional period depends not only on river water quality but also on the presence of any residual submerged terrestrial vegetation, the thermal profile of the reservoir, nutrient concentrations of submerged soil, and the rate at which reservoir water is being replaced by inflow water. Following this transitional period is a state characterized by lower concentrations of minerals and organic materials, although nutrient concentrations remain above levels found in the rivers. This lowering of reservoir fertility may prove very disappointing to a fishery that has been developing during the initial period of high fertility.

Decay of submerged terrestrial vegetation will deoxygenate the reservoir and release organic compounds into the waters, both of which lower the oxidation-reduction (redox) potential of the water. This lower potential and lack of oxygen favour certain biological reactions, in particular the reduction of sulphate to sulphide by the bacteria *Desulfovibrio* (Hutchinson, 1957). Combined with microbes that release sulphur from proteins as sulphide, these bacteria can be responsible for increasing the hydrogen sulphide concentration of the waters to a level toxic to fish and unpleasant for human use. The low solubility products of sulphide and heavy metal ions can result in large-scale precipitation of metallic sulphides that may interfere with turbine operation. Working turbine generator parts that contact reservoir water may corrode and not function properly if made of materials that can form metallic sulphides (e.g., copper). Substitutes for these materials should be investigated.

With proper watershed control of erosion and sanitation practices, noxious algal blooms are not as likely to be a problem except during the transitional period following dam closure. Eroded materials can serve as a direct source of nutrients if they originate from soils with leachable nitrogen, phosphorus, sulphur and trace elements. However, even minerals resistant to decomposition can promote the process of eutrophication by providing a substrate on which organic materials can be adsorbed and concentrated. Bacteria colonize these particles and recycle the nutrients for algae by decomposing adsorbed organic matter.

Reservoirs have a high water inflow relative to volume so that reservoir productivity is determined to a great extent by the quality of incoming rivers. Special attention should therefore be given to the water quality of inflowing rivers. A continuous water quality monitoring programme should be established with any impoundment project to monitor important ions in rivers flowing to the proposed reservoir. Bioassays performed to determine macro- and micronutrients limiting primary productivity would also be informative (Goldman, 1972b) and helpful for designing appropriate watershed management programmes.

The existing productivity of river water can be determined in a number of ways. One method is to measure its primary productivity directly. Another method is to add river water to algal cultures and measure the resulting changes in productivity. This latter technique is a bioassay of river water and is best performed on natural plankton communities found in the area.

Bioassays to determine the most likely limiting factor should also be performed using water from the inflowing river to the proposed reservoir with varying levels and combinations of N, P, Si, Fe and trace elements (Goldman, 1963 and 1967). The most likely limiting factor can then be utilized in developing strategies for lake management.

Stratification in tropical lakes is still an inadequately understood phenomenon but one of very great importance. Deep lakes stratify during the summer with a warmer surface layer (the epilimnion) at the top and a cooler layer (hypolimnion) below. Decaying organic matter in deeper waters consumes oxygen so that the hypolimnion is often depleted. Altitude, wind exposure, basin shape, and the temperature and turbidity of inflowing waters are all important variables in determining stratification.

Reservoirs in the tropics with steep sides and protection from winds are most likely to be permanently stratified. Mixing of waters may occur in the tropics, but often at such a slow rate that deoxygenation of the hypolimnion persists (Beadle, 1966). Cooling of shallow littoral water has

been proposed as a slow mixing method in tropical lakes by Beadle (1966) and was shown by Talling (1963) to occur in Lake Albert.

Modelling of the thermal characteristics of reservoirs has been accomplished in temperate latitudes, and there are excellent prospects for achieving relatively accurate predictions in tropical areas.

The placement of dam outlets in relation to stratified layers of the reservoir has important implications for downstream fisheries and agriculture. Water from the hypolimnion may be much cooler than downstream waters and may shock the fishery below. Warmer epilimnetic waters, on the other hand, may be too warm for some species. It is essential that these potential effects be evaluated so that reservoir operation can be adjusted appropriately (e.g., variable level discharges).

One of the many lessons emerging from experiences with dams in Africa is the seriousness of the threat of infestation with aquatic macrophytes. The water fern (*Salvinia auriculata*) and water lettuce (*Pistia stratiotes*) invaded Lake Kariba on the Zambesi shortly after it began to fill in December 1958 (Harding, 1966). Eventually the water fern severely hampered multipurpose use of the lake and a buoy-barrier had to be constructed to keep higher aquatic plants away from turbine inlets (Coche, 1975).

Occasionally, for reasons unknown, a lake or reservoir may remain completely free from macrophytic infestation even through a source of infection is present and the water characteristics appear to resemble other areas which do suffer. For example, water hyacinth has not colonized certain areas apparently suited for it (Little, 1966).

Important characteristics of potential aquatic weed problems include: (*a*) the presence of aquatic weeds in the watershed and within naturally transportable distances, (*b*) the presence of protected swamps or littoral areas suitable for colonization, and (*c*) the presence of submerged terrestrial vegetation to serve as protection for weed colonies.

Large stands of higher aquatics influence many aspects of reservoir use. One of their benefits to man is to provide additional food for desirable herbivorous fish or for fish feeding on organisms whicn are favoured by the protection and food offered by the higher aquatic plant habitat. Dense growth of these macrophytes may also serve to protect fish, particularly smaller fish, from excessive predation.

The negative aspects of the presence of aquatic macrophytes, however, overwhelmingly point to the need to control their growth:

1. Decomposition of the macrophytes by aerobic bacteria can contribute to an extensive deoxygenation of the reservoir waters, the chemical effects of which have been mentioned. In addition, the lower deoxygenated waters will not be able to support fish populations, and plant productivity in this region will thus go unharvested.

2. Huge thick floating mats (sudds), sometimes sufficiently large to support growth of other higher plants (e.g., *Scirpus cubensis* on *Salvinia*) can present real hazards to navigation and plug turbine intakes.

3. Heavy infestations can interfere with operation of gill-nets and seines and seriously hamper commercial as well as sport fishing.

4. Certain disease-bearing organisms (e.g., the snail vector of schistosomiasis and the mosquito vector of malaria) find desirable habitats among these macrophytic "forests."

5. The volume of these plants may displace significant amounts of water and thus reduce reservoir capacity during times of overflow.

6. The macrophytes transpire tremendous amounts of water, perhaps five times the amount evaporating from a water surface of equivalent area. Thus, the 20 percent cover of water fern found on Lake Kariba in 1962 probably doubled the evapotranspiration rate!

A detailed study should be made of the occurrence and relative abundance of the animal and plant life in the area to be inundated. Since dam construction results in the loss of the riparian and watershed habitats to be inundated, these areas should be studied both with respect to the losses in vegetation that would occur and the effects this submerged and decaying vegetation would have on the proposed reservoir. The submergence of vegetation is a particular problem in the tropics since tropical forests hold more nutrients relative to the soil than temperate areas (Freeman, 1974). Large amounts of nutrients will be released to the lake and deoxygenation will occur in the hypolimnion through decay of these rotting plant materials. The Siranumum Dam near Port Moresby, Papua New Guinea, has a hydrogen-sulphide-rich outflow because terrestrial vegetation was not removed and decay resulted in increased levels of hydrogen sulphide in the hypolimnion. Hydrogen sulphide is very corrosive to metal and can destroy turbine parts and electrical connections.

Rotting vegetation is best controlled by removal and it is often recommended that the entire area to be inundated should be clear-cut and the vegetation removed or burned. Burning terrestrial vegetation is less desirable, however, since it will permit nutrients released by the destroyed terrestrial vegetation to be quickly utilized by aquatic plants (Ewer, 1966). However, the cost of physically removing terrestrial vegetation from the watershed is often prohibitive.

The control of higher aquatic plants has been accomplished using mechanical harvesting, although the quipment, expense, and the steep sides of a reservoir make this an impractical solution. Chemical control, especially with 2,4-D which is harmless to fish, has been successfully utilized, but toxicity to downstream agriculture suggests that its use be as limited as possible. In addition, by returning the plant nutrients to the reservoir waters, chemical applications merely prolong the problem.

Biological control of higher aquatic plants is the most desirable method, but experiments with manatees, snails, insects and herbivorous fish have yet to show great promise.

Infestation must be prevented in its earliest stages, control methods being expensive or ineffective once exponential growth is under way. Pre-

vention consists of both limiting infection sources and controlling the chemical environment of these plants. In Ghana, at the Volta Dam, it was realized that close guard was required to prevent infestation. Posters were printed in eight languages displaying papyrus, *Eichornia* and *Salvinia*, asking that persons seeing these plants report them immediately to the authorities. It was recommended (Goldman, 1972a) that lake patrols be established if El Cajon Dam were to be constructed in Honduras, for the purpose of regularly surveying the reservoir shoreline and removing any observed macrophyte growth.

Although it would be disastrous to encourage high yields of aquatic macrophytes in the reservoir, it may be noted that the Chinese have found water hyacinth and water lettuce to be an excellent duck and pig fodder.

Analysis of all wildlife values, including habitats, ranges, migrations, and the presence of endemic or rare species that might be affected by the proposed dam, should be considered. It was found at the El Cajon site that the original biotic communities of the proposed catchment area had already been severely damaged by the activities of man, including swidden agriculture, poor forestry practices and burning. It was concluded that the biological interest of the area could be enhanced if swidden agriculture and burning were abandoned and a renewed stand of timber was encouraged. It was recommended in this study that immediate steps be taken to prevent the lumbering or clear-cutting of the few remaining stands of virgin timber in the watershed of the proposed reservoir. Not only would conservation of large tracts of broad-leaf and coniferous forests help to maintain the relatively low silt levels observed in the Rio Yure, but the forests could also serve as source areas for faunal and floral repopulation of the watershed.

One of the trade-offs in converting a large area of terrestrial habitat to an aquatic one is the potential development of viable fisheries. This can be of great importance in areas where the average protein intake is low and where agriculture is at a marginal level. There is, however, a tendency to overestimate the production and overfish the stock of reservoirs. Fish production rose in Lake Kariba along with the total dissolved solids (TDS) during the filling stage only to decline drastically in 1963 (Balon and Coche, 1974). The decline coincided with a drop in TDS from 81 to 63 ppm.

The best means of achieving a high protein-yield from an inland fishery is to promote the growth of species that feed on plant rather than animal food. There is a great loss in available food energy at each transfer of energy from herbivore through successively larger carnivorous fish.

The importance and complexity of fisheries development merits the creation of some permanent body to research the various problems and develop stringent laws to protect the new fishery. It is always easier to relax old laws rather than institute new ones which conflict with people's newly acquired habits.

Consideration of the potential ecological effects of dam construction should not be limited to the catchment area but should be extended to downstream effects as well. The decreased silt in waters downstream from the impoundment has significant effects on the nutrient load, and hence productivity, of these waters.

Nutrients contained in or bound to river-borne particulate matter have a fertilizing effect on the land and on ocean waters near rivers. This may contribute significantly to the productivity of existing coastal fisheries. The removal of this silt can decrease phytoplankton photosynthesis which in turn decreases fish productivity. An example of this probably occurred in the eastern Mediterranean, where sardine catches decreased in volume following the closure of the Aswan High Dam.

A similar problem exists with the effects of reduced silt load on the fertilization of river valley agricultural lands. Flood plains are normally very rich areas of vegetative growth and agriculture, but the richness can slowly be lost by the lack of nutrient renewal during flooding. A decrease in traditional agriculture has been reported in the flood plains below the Volta Dam (Hilton and Kown-tsei, 1972), and Lake Kariba apparently does not produce the protein that the area was capable of producing prior to the dam.

Besides changes in silt content, certain other parameters of downstream water quality will be altered by chemical and biological processes occurring in the reservoir. For example, water removed from the reservoir hypolimnion may be deoxygenated and laden with hydrogen sulphide which can alter its usefulness as a domestic and industrial water source.

Only actual surveys of downstream and coastal fisheries and wildlife resources enable protective measures to be planned and implemented before completion of the dam, and such surveys are strongly recommended. The Gulf of New Guinea, for example, could be greatly altered from its currently rich fishery potential by a complete hydroelectric development of the Purari river system.

The possibility that changes in the sediment load carried to the sea can alter patterns of beach and bay formation is of serious concern. Sandy beaches, by nature of their small extent, are a valued commodity in the world for their aesthetic, scientific and recreational interest. Water storage projects throughout the world have reduced the sand formation process and in many areas, including much of the eastern seaboard of the United States, beaches are being continuously reduced. In some cases tourist industries have been adversely affected.

The effect of impoundment on coastal wildlife resources also deserves special attention since these coastal areas are essential to the maintenance and reproduction of many valuable and endangered wildlife species.

Deltas and their associated estuaries are especially rich and dynamic areas in which sediment loads are deposited, resuspended and redeposited (Tison, 1964; Mikhailov, 1964). Altered flow rates and sediment loads can have particularly dramatic effects in these areas, particularly in relation to the distance of salt water intrusion (Goldman, 1971). The delta environment remains one of the richest of all ecosystems. Any alteration of its fertility should be viewed with great concern and the long-term cost/benefits reviewed with care.

EROSION ALONG A ROAD NEAR THE SURINAMU RESERVOIR IN PAPUA NEW GUINEA
a common and serious source of sediment

An increase in health problems often accompanies the creation of large reservoirs in the tropics. The high concentration of people and the low level of sanitation common to work camps of the dam labour force create an ideal environment for the spread of malaria, dysentery, tuberculosis, venereal disease, etc. The labour force is both a source of new diseases and its people are highly susceptible to endemic diseases. The large population entering a previously sparsely inhabited region provides high host densities, thereby increasing the likelihood of the spread of many diseases. At different stages of dam construction in the tropics, increases and decreases in malaria, dysentery, schistosomiasis and onchocerciasis have been reported (Kershaw, 1966; Waddy, 1966; Warmann, 1969; Obeng, 1969; Paperna, 1969).

Factors relevant to vector ecology should receive special attention. Disease-causing agents, vectors, and the nutritional status of the people are all important variables in physical health and should be considered in evaluating the impact of hydroelectric dam projects. Methods of preventing health hazads associated with the project must be developed at an early stage in the planning process.

Health records in the El Cajon area reveal that aside from basic malnutrition, the most prevalent diseases in the area are tuberculosis, typhoid, dysentery and malaria. In the Purari delta area and coast, gastro-intestinal problems are common as well as a high incidence of malaria and tuberculosis.

It has been found in Africa that the stress associated with resettlement of the people inhabiting the water project site significantly increases disease and mortality, particularly among the very young and the very old. Therefore, it can be expected that the incidence of any diseases occurring at the site is likely to increase, and steps should be taken to offset this probability.

Aside from the necessity of an intensive health survey of the area and an inoculation programme, it should

be pointed out that in the period of transition, normal cultivation will be interrupted, and the people's diet will be more tenuous than ever. Therefore, it is essential that the people receive sufficient nourishment during this transitional period until new communities are established. This could include milk programmes for children and food supplements for the families involved.

Malaria is endemic in most tropical areas of the world. Submerged trees and swampy higher aquatic plant habitats encourage the development of *Anopheles* mosquitoes, certain species of which carry the various malaria-causing protozoa. Mosquito habitats obviously must be avoided in the reservoir, and it is probable that the steep reservoir sides and fish population will provide adequate control over much of the areas. In view of the relatively high human population densities that the building of the dam will introduce into localized sections of the catchment area, anti-malarial prophylactic measures must be stringently followed.

Schistosomiasis bears certain ecological similarities to malaria since snail vectors (such as *Bulinus* and *Biomphalaria*) of the parasitic blood fluke (*Schistosoma* spp.) is favoured by submerged trees and higher aquatic plants. Transmission takes place, however, not through biting, but by penetration of humans by the free-swimming cercaria stage of the fluke. Although no cases were reported in Honduras, *Biomphalaria*-bearing *Schistosoma mansoni* does occur in South America and the Caribbean. Schistosomiasis has increased in association with water development in Rhodesia (Schiff, 1972) and Ghana (Paperna, 1969). Preventive measures include the destruction of terrestrial vegetation and control of higher aquatic vegetation as in the case of malaria. If schistosomiasis is not endemic to the area under consideration, detailed medical examinations should be performed on all personnel associated with the dam project in order to prevent the introduction of the disease. In addition, a careful survey should be made of aquatic habitats in the vicinity for possible snail hosts.

Onchocerciasis, or "river blindness", is a disease caused by the nematode *Onchocerca* which is transmitted to humans by the bite of the black fly, *Simulium* spp. The common name of the disease originates from the fact that blindness is produced in some of the victims. These black flies can breed effectively only in swiftly flowing and well-oxygenated waters, an environment which characterizes the catchment area rivers and which will decrease in extent as the reservoir basin fills (Waddy, 1966). In other words, the likelihood of onchocerciasis will diminish as a new dam slows the movement of water into the area and decaying vegetation produces deoxygenation in the reservoir. During construction on the Volta river DDT was used to control *Simulium* spp. larvae. Attention below the dam is, of course, warranted as this area with lowered sediment transport may improve as a *Simulium* habitat. Further, there is the possibility that migrant labour could bring the disease into the area.

Gastro-intestinal problems (such as dysentery) attributable to water contact continue to be a common health problem in the tropics. Although the inevitable increase in human contact with the surface waters of the catchment area following completion of the dam will introduce protozoa and bacteria, the removal from the watershed of people not connected with construction of the dam would reduce human sources of infestation. This tactic should be combined with adequate treatment of drinking water supplies and wastewater produced by people remaining in the area.

The past history of watershed management provides global evidence of the need to anticipate sewage-treatment requirements. Lack of such foresight has resulted repeatedly in undesirable eutrophication and loss of sanitary water supplies. Therefore, a wastewater treatment study should be initiated that would provide future watershed populations with satisfactory treatment facilities. A series of strategically located small secondary treatment plants and septic tanks near population centres on the watershed is indicated by past experience to be an absolutely necessary investment.

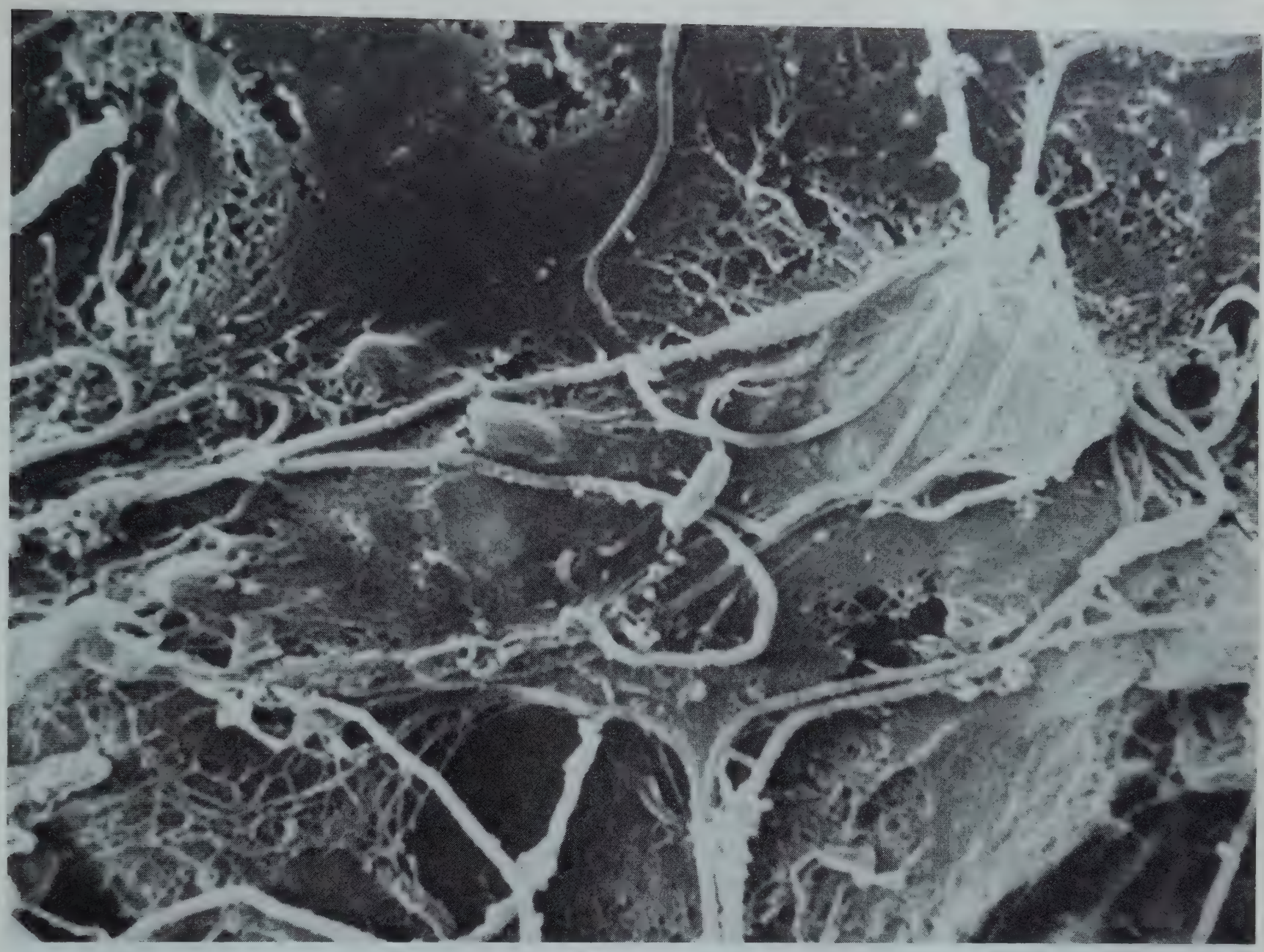
Impoundment projects in the tropics often necessitate the relocation or resettlement of people inhabiting the area. Whenever possible, large-scale resettlement schemes should be avoided. However, if resettlement is found to be mandatory, several factors must be considered. First, it is essential that population relocation be recognized as an integral and important part of the hydroelectric project, and that local people be actively involved in the planning of resettlement.

The proposed Wabo Project in Papua New Guinea provides a good example of a small resettlement project; approximately 300-500 people and three villages would be displaced by inundation. A thorough understanding of their social structure and careful consideration of their opinions about resettlement were found to be essential in formulating relocation plans. Assessment of their spiritual and physical attachments to the land would help prevent resentment over evacuation. The Government's handling of these people will be a major factor in establishing their relationship to the Government and in the social success or failure of the entire project.

Careful consideration should be given to the touristic value of the impoundment area as compared to the touristic value of the proposed reservoir. The recreational use of an area is enhanced (in most cases but certainly not all) by water, and care must be exercised in promoting a hydroelectric project on the basis of its recreational benefits.

In view of the changing shoreline of the reservoir and the primary function of the watershed as erosion control combined with the need to protect developing fisheries, it is recommended that no tourist or recreational development be considered until the reservoir has been filled for several years. Only when the water quality has somewhat stabilized, the characteristics of the fish population are known, and the biologically important areas of the terrestrial part of the watershed have been studied should recreational facilities be considered.

The possibility of valuable archaeological sites existing in the area should be investigated carefully to ensure proper excavation by archaeologists



FILAMENTOUS BACTERIA ON A DETRITAL PARTICLE MAGNIFIED 10 900 TIMES

a garbage collector

well before inundation is due to begin.

Of considerable importance are the secondary impacts of impoundment projects caused by increased development made possible by the availability of electrical power and the potential for industrial development.

An evaluation of the anticipated long-range effects of any project is at best speculative. Nonetheless, attention must be focused on the spectrum of most likely environmental impacts in order to facilitate their future management and help the project become a rational component of future development for the region and nation involved.

Natural resources such as timber and mineral or petroleum reserves are usually much more effectively exploited by the development of electrical power. If an industrial complex is planned as part of a new dam project, it should be described and brief scenarios of the potential impacts of alternative plans for utilization of these resources made. Primary impacts of the industrial complex associated with the water project will include the construction of facilities on natural areas, pollution, and increased utilization of renewable and non-renewable resources.

In addition, during construction of any water development project impacts particular to construction will arise. For example, road development in previously unopened areas causes a series of ecological impacts including increased levels of erosion both during and after road construction. Further, the road serves as an avenue of travel for diseases and pests. The transportation of construction crews and equipment by barges will also have ecological and sociological impacts.

Secondary impacts on environment and social life result from any irrigation or water diversion and subsequent agricultural changes. The decision to embark on comprehensive development of the area should be based on a careful study of the problems and advantages of replacing naturally balanced ecosystems with man-made ones. Effects on the nation's health, nutrition, style and standard of living, land-use patterns and population growth rate should receive particular attention. In every case it is essential that local leadership become involved at an early stage and be provided with a broad view of both primary and

FLOATING AND EMERGENT LAKE VEGETATION

not yet a hindrance to boats and fishing, but trouble enough for a power plant

secondary impacts of the proposed project. ■

References

BALON, E.K. & COCHE, A.G. (eds). 1974 *Lake Kariba: a man-made tropical ecosystem in Central Africa.* The Hague, Dr. W. Junk Publishers, 767 p.

BEADLE, L.C. 1966 Prolonged stratification and deoxygenation in tropical lakes. Part 1: Crater Lake, Nkugute, Uganda, compared with Lakes Bunyoni and Edward. *Limnol. Oceanogr.* 11(2): 152-163.

COCHE, A.G. 1974 Limnological study of a tropical reservoir. In *Lake Kariba: a man-made tropical ecosystem in Central Africa.* p. 1-246. The Hague, Dr. W. Junk Publishers.

EWER, D.W. 1966 Biological investigations on the Volta Lake, May 1964 to May 1965. In *Man-made lakes*, (ed. R.H. Lowe-McConnell), p. 21-31. New York, Academic Press.

FREEMAN, P.H. 1974 *The environmental impact of tropical dams.* Guidelines for impact assessment based upon a case study of Volta Lake. Washington, D.C., Smithsonian Institute.

GOLDMAN, C.R. 1963 The measurement of primary productivity and limiting factors in freshwater with Carbon 14. In *Proceedings*, Conference on primary productivity measurement, marine and freshwater (ed. M.S. Doty), p. 103-113. US Atomic Energy Commission, TID-7633.

GOLDMAN, C.R. 1967 Integration of field and laboratory experiments in productivity studies. In *Estuaries* (ed. G.H. Lauff), p. 346-352. Publication No. 83, American Association for the Advancement of Sciences, Washington, D.C.

GOLDMAN, C.R. 1971 Reduced flows and the future ecology of the San Francisco-Bay Delta System. Miami, Florida. *Proc. Symp. Hydrobiol.*, 8: 174-190.

GOLDMAN, C.R. 1972a El Cajon Project. Feasibility Study 5. *Ecology.* Prepared for Motor Colombus Consulting Engineers, Inc. and the World Bank with the support of Empresa National de Energía Electrica, Tegucigulpa, Honduras, 59 p.

GOLDMAN, C.R. The role of minor
1972b nutrients in limiting the productivity of aquatic ecosystems. In *Nutrients and eutrophication* (ed. G.E. Likens), p. 21-33. Amer. Soc. Limnol. Oceanog. Spec. Symp. No. 1.

GOLDMAN, C.R., HOFFMAN, R.W. &
1973 ALLISON, A. *Environmental studies design, Purari River Development, Papua New Guinea.* E.R.A. for United Nations Development Program, New York.

HARDING, D. Lake Kariba — the
1966 hydrology and development of fisheries. In *Man-made lakes* (ed. R.H. Lowe-McConnell), p. 7-20. London, Academic Press.

HILTON, T.E. & KOWN-TSEI, J.Y. The
1972 impact of the Volta scheme on the lower Volta flood plains. *J. Trop. Geogr.*, 1972: 29-37.

HUTCHINSON, G.E. *A treatise on lim-*
1957 *nology*. Vol. 1. New York, John Wiley and Sons, Inc. 1015 p.

KERSHOW, W.E. The simulium problem
1966 and fishery development in the proposed Niger lake. In *Man-made lakes* (ed. R.H. Lowe-MacConnell), p. 95-98. New York, London, Academic Press.

LITTLE, E.C.S. The invasion of man-
1966 made lakes by plants. In *Man-made lakes* (ed. R.H. Lowe-McConnell), p. 75-86. New York, London, Academic Press.

MIKHAILOV, V.M. Hydrology and for-
1964 mation of river-mouth bass. Unesco *Humid Tr. Res.*, 24(2): 59-64.

OBENG, L.E. The invertebrate fauna
1969 of acquatic plants of the Volta lake in relation to the spread of helminth parasites. In *Man-made lakes* (ed. L.E. Obeng), p. 320-325. Accra, Ghana University Press.

PAERL, H.W.W. & GOLDMAN, C.R.
1972a Heterotrophic assays in the detection of water masses at Lake Tahoe, California. *Limnol. Oceanog.*, 17(1): 145-148.

PAERL, H.W. & GOLDMAN, C.R. Stim-
1972b ulation of heterotrophic and autotrophic activities of a planktonic microbial community by siltation at Lake Tahoe, California. *Mem. Inst. Idrobiol.*, 29 Suppl.: 129-147.

PAPERNA, I. Snail vectors of human
1969 schistosomiasis in the newly formed Volta lake. In *Man-made lakes* (ed. L.E. Obeng), p. 326-330. Accra, Ghana University Press.

SCHIFF, C.J. The impact of agricultural
1972 development on aquatic systems and its effects on the epidemiology of schistosomiasis in Rhodesia. In *The careless technology* (eds M.T. Farvar and J.P. Milton), p. 102-108. Garden City, New York, Natural History Press.

TALLING, J.F. Origin of stratification
1963 in an African rift lake. *Limnol. Oceanogr.*, 8(1): 68-78.

TISON, L.J. Problèmes de sédimentation
1964 dans les deltas. *Humid Tropics Res.*, Unesco 24(2): 57 (Summary).

WADDY, B.B. *Medical problems arising*
1966 *from the making of lakes* (ed. R.H. Lowe-McConnell), p. 87-94. London, New York, Academic Press.

WARMANN, J. ST. G. Onchocerciasis
1969 and the Volta Dam construction. In *Man-made lakes* (ed. L.E. Obeng), p. 352. Accra, Ghana University Press.

Present and future natural forest and plantation areas in the tropics

J.P. Lanly and **J. Clement**

By the year 2000 net removals from tropical forests should be 2.5 times those of 1975 and economic and population pressures, especially those for fuel wood, will cause local shortages.

The FAO Expert Consultation on World Pulp and Paper Demand, Supply and Trade, which met in Tunis from 20 to 22 September 1977, recommended that in order that there might be a more realistic appraisal of wood supply for pulping, FAO, in collaboration with a modified Industry Working Party, extend the "World pulp and paper consumption outlook" study[1] to cover all forest products, including fuelwood and related total demand to the prospective supply of roundwood from the world's forests.

It was agreed then that FAO would carry out the "resource outlook for fibre" of the developing world, within the proposed overall study of world demand for hardwood and softwood fibre products. More precisely, FAO

[1] The "World pulp and paper consumption outlook", presented at this meeting to the FAO Advisory Committee on Pulp and Paper, forecast until 1990 consumption of paper and paperboard, interregional trade in paper and paperboard (and corresponding fibre furnish), and consumption of white chemical pulp.

The origin of this article

This article is derived from a document issued by FAO in May 1979 entitled "Present and future forest and plantation areas in the tropics" (miscellaneous paper FO: MISC/79/1) by the two authors.

The results of this desk study carried out at FAO Headquarters were not discussed with the concerned national institutions because of the short time available, except in a few cases. FAO is at present engaged in collaboration with the United Nations Environment Programme (UNEP) in a more detailed reassessment of tropical forest resources which will be reviewed by the countries concerned before final publication.

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has been in charge of assessing the resource base and wood supply as well as their evolution until the year 2000, for the three following developing regions:

— Latin America and the Caribbean, that is, America south of the United States;
— Africa south of the Sahara (without South Africa); — Asia and the Far East (without part of the USSR, China, the Democratic People's Republic of Korea and Mongolia). The developing countries included in this study are all tropical, plus several adjacent temperate countries (see box).

Given the short time available — this part of the study started in March 1978 and the overall demand/supply outlook was to be completed by September 1978 — and the industrial objective of the study, it was decided that fuelwood (and charcoal) would not be considered among the fibre products, despite their importance in most developing countries and the possible effect on industrial wood supply. In the assessment of the resource base, distinction was therefore made between those forests (natural or man-made) producing industrial wood and those providing only fuelwood or wood for charcoal.

Central and South America

Natural hardwood forests. In 1975 there were in Central and South America approximately 823 million hectares of natural hardwood forests, of which 788 million were tropical — or 45 percent of all tropical forests — and 35 million temperate in Argentina, Chile and Uruguay. The largest part of the tropical hardwood forests are in the Amazon basin, mainly in Brazil. Of these, 80 percent are closed forests representing 56 percent of the world area of tropical closed hardwood forests. Although 487 million hectares are operable, most of them

Table 1. Estimated areas of natural forests at end of 1975
(Thousand hectares)

Regions/subregions	Hardwood closed			Softwood			Hardwood closed and softwood			Hardwood open
	Productive	Unproductive	Total	Productive	Unproductive	Total	Productive	Unproductive	General total	
Tropical America										
Central America	19 391	37 962	57 353	20 111	4 250	24 361	39 502	42 212	81 714	14 631
CARICOM	14 411	5 330	19 741	246	182	428	14 657	5 512	20 169	146
Other Caribbean	22 544	1 288	23 832	422	676	1 098	22 966	1 964	24 930	4
Tropical south Latin America	430 626	95 788	526 414	5 380	700	6 080	436 006	96 488	532 494	146 472
Total	486 972	140 368	627 340	26 159	5 808	31 967	513 131	146 176	659 307	161 253
Temperate South America	8 669	5 251	13 920	561	177	738	9 230	5 428	14 658	20 874
Total Central and South America	495 641	145 619	641 260	26 720	5 985	32 705	522 361	151 604	673 965	182 127
Tropical Africa										
Northern savanna region	20	155	175	0	0	0	20	155	175	52 356
West Africa	12 133	1 951	14 084	0	0	0	12 133	1 951	14 084	48 595
Central Africa	115 355	55 290	170 645	0	0	0	115 355	55 290	170 645	154 600
East Africa and islands	6 306	10 569	16 875	369	1 505	1 874	6 675	12 074	18 749	145 064
Developing tropical southern Africa	0	0	0	0	0	0	0	0	0	43 010
Total	133 814	67 965	201 779	369	1 505	1 874	134 183	69 470	203 653	443 625
Developing temperate southern Africa	0	0	0	0	0	0	0	0	0	2
Total Developing Africa south of Sahara	133 814	67 965	201 779	369	1 505	1 874	134 183	69 470	203 653	443 627
Tropical Asia and Far East										
South Asia	48 889	12 520	61 409	6 655	2 955	9 610	55 544	15 475	71 019	5 026
Continental Southeast Asia	30 091	7 521	37 612	707	0	707	30 798	7 521	39 319	10 674
Insular Southeast Asia	76 101	54 589	130 690	479	0	479	76 580	54 589	131 169	0
Centrally planned tropical Asia	17 011	3 421	20 432	848	230	1 078	17 859	3 651	21 510	15 667
Oceania developing	15 846	25 230	41 076	10	14	24	15 856	25 244	41 100	4 266
Total	187 938	103 281	291 219	8 699	3 199	11 898	196 637	106 480	303 117	35 633
East Asia developing	2 480	1 449	3 929	2 149	677	2 826	4 629	2 126	6 755	0
Total Developing Asia and Far East	190 418	104 730	295 148	10 848	3 876	14 724	201 266	108 606	309 872	35 633
TOTAL TROPICAL COUNTRIES	808 724	311 614	1 120 338	35 227	10 512	45 739	843 951	322 126	1 166 077	640 511

cannot be considered as intensively managed. It is quite difficult to estimate reliably the areas which have already been logged over, but the percentage of undisturbed forests is high and probably reaches over 95 percent of the operable closed forests.

The estimate of the total area of closed hardwood forests by the year 2000 is 575 million hectares. The total decrease with respect to 1975 is thus estimated at 66 million hectares, almost exclusively for the tropical closed forests, of which more than 10 percent will have been depleted by the year 2000. Depletion will occur mostly along the Pacific coast of South America (Colombia, Ecuador) and in the Amazon basin. If, however, we consider the depletion trends at the national level, the forests of Central America will suffer the largest relative decrease: 17.6 million hectares in 1975 against 12.5 million in the year 2000 — a decrease of 29 percent for the whole of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. More and more detailed harvesting regulations may be enforced in the operable forests, but no intensive management system is contemplated on large areas during that period. As far as temperate South America is concerned, total areas will not change significantly, dropping from 13.9 million hectares in 1975 to 13.1 million in 2000, representing a 6 percent decrease, a depletion mainly due to clearings in northern Argentina for the establishment of large ranches.

Softwood forests. In 1975 South and Central America possessed 70 percent of the worlds tropical softwood forests — 32 million hectares out of

Table 2. Estimated areas of natural forests at end of 1980
(Thousand hectares)

Regions/subregions	Hardwood closed			Softwood			Hardwood closed and softwood		
	Productive	Unproductive	Total	Productive	Unproductive	Total	Productive	Unproductive	General total
Tropical America									
Central America	18 226	37 631	55 857	19 135	4 068	23 203	37 361	41 699	79 060
CARICOM	14 389	5 320	19 709	244	180	424	14 633	5 500	20 133
Other Caribbean	22 484	1 274	23 758	381	664	1 045	22 865	1 938	24 803
Tropical south Latin America	416 951	95 488	512 439	4 035	700	4 735	420 986	96 188	517 174
Total	472 050	139 713	611 763	23 795	5 612	29 407	495 845	145 325	641 170
Temperate South America	8 502	5 223	13 725	553	175	728	9 055	5 398	14 453
Total Central and South America	480 552	144 936	625 488	24 348	5 787	30 135	504 900	150 723	655 623
Tropical Africa									
Northern savanna region	20	155	175	0	0	0	20	155	175
West Africa	9 830	1 951	11 781	0	0	0	9 830	1 951	11 781
Central Africa	114 690	55 290	166 980	0	0	0	114 690	55 290	169 980
East Africa and islands	5 624	10 569	16 193	323	1 505	1 828	5 947	12 074	18 021
Developing tropical southern Africa	0	0	0	0	0	0	0	0	0
Total	130 164	67 965	198 129	323	1 505	1 828	130 487	69 470	199 957
Developing temperate southern Africa	0	0	0	0	0	0	0	0	0
Total Developing Africa south of Sahara	130 164	67 965	198 129	323	1 505	1 828	130 487	69 470	199 957
Tropical Asia and Far East									
South Asia	45 352	11 966	57 318	6 480	2 955	9 435	51 832	14 921	66 753
Continental Southeast Asia	29 238	7 521	36 759	689	0	689	29 927	7 521	37 448
Insular Southeast Asia	71 526	54 209	125 735	464	0	464	71 990	54 209	126 199
Centrally planned tropical Asia	15 111	3 421	18 532	798	230	1 028	15 909	3 651	19 560
Oceania developing	15 683	25 230	40 913	10	14	24	15 693	25 244	40 937
Total	176 910	102 347	279 257	8 441	3 199	11 640	185 351	105 546	290 897
East Asia developing	2 249	1 389	3 638	1 973	677	2 650	4 222	2 066	6 288
Total Developing Asia and Far East	179 159	103 736	282 895	10 414	3 876	14 290	189 573	107 612	297 185
TOTAL TROPICAL COUNTRIES	779 124	310 025	1 089 149	32 559	10 316	42 875	811 683	320 341	1 132 024

45.7 million — and 74 percent of operable tropical softwood forests — 26.2 million hectares out of 35.2 million. These forests are mainly situated in Central America and the Caribbean Islands, although more than five million hectares of softwood forests exist in southeastern Brazil, to which must be added some 100 000 hectares of *Podocarpus* stands in the Andes mountains, this species being often in mixture with hardwoods. Most of these forests are not intensively managed. Several have already been logged over and their sustained production in many cases is not secured. Temperate South America possesses about 0.7 million hectares of natural softwood forests in the southern part of the Andes, of which about 25 percent are inoperable.

Wood productivity is not the most important consideration in forestry. Natural forests are less productive per hectare than plantations, but their loss can be more serious...

In the year 2000 it is estimated that the remaining area of softwood forests will be 22.3 million hectares as against 32.7 million in 1975, a decrease of 10.4 million hectares or 32 percent, occurring almost entirely in the tropical zone. This depletion will take place in all countries concerned, but will be highest in Brazil — from 5.8

Table 3. Estimated areas of natural forests in the year 2000
(Thousand hectares)

Regions/subregions	Hardwood closed			Softwood			Hardwood closed and softwood		
	Productive	Unproductive	Total	Productive	Unproductive	Total	Productive	Unproductive	General total
Tropical America									
Central America	14 750	36 620	51 370	16 030	3 400	19 430	30 780	40 020	70 800
CARICOM	14 310	5 270	19 580	240	170	410	14 550	5 440	19 990
Other Caribbean	22 260	1 230	23 490	230	630	860	22 490	1 860	24 350
Tropical south Latin America	373 350	94 040	467 390	220	700	920	373 570	94 740	468 310
Total	424 670	137 160	561 830	16 720	4 900	21 620	441 390	142 060	583 450
Temperate South America	7 990	5 150	13 140	530	170	700	8 520	5 320	13 840
Total Central and South America	432 660	142 310	574 970	17 250	5 070	22 320	449 910	147 380	597 290
Tropical Africa									
Northern savanna region	20	160	180	0	0	0	20	160	180
West Africa	5 500	1 950	7 450	0	0	0	5 500	1 950	7 450
Central Africa	110 460	55 290	165 750	0	0	0	110 460	55 290	165 750
East Africa and islands	3 130	10 570	13 700	200	1 510	1 710	3 330	12 080	15 410
Developing tropical southern Africa	0	0	0	0	0	0	0	0	0
Total	119 110	67 970	187 080	200	1 510	1 710	119 310	69 480	188 790
Developing temperate southern Africa	0	0	0	0	0	0	0	0	0
Total Developing Africa south of Sahara	119 110	67 970	187 080	200	1 510	1 710	119 310	69 480	188 790
Tropical Asia and Far East									
South Asia	35 250	10 560	45 810	5 920	2 920	8 840	41 170	13 480	54 650
Continental southeast Asia	26 090	7 520	33 610	630	0	630	26 720	7 520	34 240
Insular southeast Asia	56 070	53 030	109 100	430	0	430	56 500	53 030	109 530
Centrally planned tropical Asia	11 010	3 420	14 430	600	230	830	11 610	3 650	15 260
Oceania developing	14 900	25 230	40 130	10	10	20	14 910	25 240	40 150
Total	143 320	99 760	243 080	7 590	3 160	10 750	150 910	102 920	253 830
East Asia developing	1 350	1 150	2 500	1 270	680	1 950	2 620	1 830	4 450
Total Developing Asia and Far East	144 670	100 910	245 590	8 860	3 840	12 700	153 530	104 750	258 280
TOTAL TROPICAL COUNTRIES	687 100	304 890	991 990	24 510	9 570	34 080	711 610	314 460	1 026 070

million in 1975 to 0.8 million in 2000.

This extremely important depletion of natural tropical softwood forests brings up the problem of the conservation of pine ecotypes, particularly in the Caribbean, but also in other tropical countries where they are used for afforestation.

Industrial plantations. Always keeping the year 1975 as a base for our estimates, we find that 94 percent of industrial plantations are located in South America and only 6 percent most heavily endowed with industrial plantations.

Africa — South of the Sahara

Natural forests. In 1975 tropical Africa was covered by 645 million hectares of tropical hardwood forests, about 37 percent of the world's tropical forests. This consisted of 443 million hectares of open forests and 202 million of closed forests. The latter figure corresponds to only 18 percent of the world's closed tropical forests. hectares, of which 65 million are in Zaire, 14.2 million in Cameroon, 8.8 million in the Congo and 13.4 million in Gabon. Although these closed forests contain in volume generally more than 300 m^3 per ha (all species more than 20 cm DBH, bole plus branches), the bole volume of the trees more than 60 cm DBH is only 60 to 120 m^3 per ha, of which 6 to 10 m^3 are at present being extracted as commercial logs. The overwhelming majority of these forests are managed neither intensively nor ex-

The countries concerned

From a total of 146 countries, 96 were studied in depth. The others have no significant forest resources potential between now and the year 2000. Those studied in depth have been grouped in the tables as follows:

TROPICAL AMERICA

Latin America - Central America

Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua

CARICOM (Caribbean Common Market)

Belize, Jamaica, Trinidad and Tobago

Other Caribbean

Bahamas, Cuba, Dominican Republic, Guadeloupe, Guyana, Haiti, Martinique, Suriname

Tropical south Latin America

Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Venezuela

Temperate South America

Argentina, Chile, Peru

TROPICAL AFRICA

Northern savanna region

Cape Verde, Chad, Gambia, Mali, Mauritania, Niger, Senegal, Upper Volta

West Africa

Benin, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Nigeria, Sierra Leone, Togo

Central Africa

Angola, Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Sao Tomé and Principe, Zaire

East Africa and islands

Burundi, Djibouti, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Rwanda, Somalia, Sudan, Tanzania, Uganda, Zambia

Developing tropical southern Africa

Botswana, Namibia, Rhodesia

Developing temperate southern Africa

Lesotho, Swaziland

TROPICAL ASIA AND FAR EAST

South Asia

Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka

Continental Southeast Asia

Burma, Thailand

Insular Southeast Asia

Brunei, Indonesia, Malaysia, Philippines

Centrally planned tropical Asia

Democratic Kampuchea, Lao, Viet Nam

Developing Oceania

Fiji, New Caledonia, New Hebrides, Papua New Guinea, Solomon Islands, Western Samoa

Developing East Asia

Republic of Korea, insular China (Taiwan)

in Central America. Of those in the tropical area, 91 percent are in South America, mostly in Brazil. They are equally distributed between hardwoods, mainly eucalypts, and softwoods, mainly pines. The proportion of plantations for non-industrial purposes is the lowest of the three tropical regions.

The share of tropical South America, and particularly Brazil, in industrial plantations within tropical America is expected to remain above 90 percent until the year 2000, by which time this region will, of the three, be the

Open forests exist in all subregions in the form of more or less wooded savannas of which 75 percent can be considered operable for production of timber and pitprops. Closed forests are chiefly lowland moist forests located mainly in central Africa — 171 million hectares, of which 115 million operable over a total of 134 million operable for the whole of tropical Africa.

Forests not yet covered by logging represent about 90 percent of the forests of central Africa: 104 million

tensively, apart from 400 000 hectares in West and East Africa.

In the year 2000 the estimated total area of closed tropical forests will be 187 million hectares, corresponding to a decrease of 15 million hectares, or 7.5 percent. This decrease will be unequally distributed among subregions: in West Africa they will be reduced from 14 million hectares in 1975 to 7.5 million, a 47 percent decrease; in East Africa, 16.8 million hectares against 13.7 million, an 18 percent decrease; central Africa, which

Table 4. Estimated areas of plantations at end of 1975
(Thousand hectares)

Regions/subregions	Hardwood			Industrial		Non-industrial
	Low yielding	High yielding	Total	Softwood	Hardwood and softwood total	Hardwood and softwood
Tropical America						
Central America	9	9	18	15	33	59
CARICOM	14	0	14	13	27	—
Other Caribbean	15	50	65	44	109	40
Tropical south Latin America	110	730	840	888	1 728	462
Total	148	789	937	960	1 897	561
Temperate South America	80	181	261	628	889	242
Total Central and South America	228	970	1 198	1 588	2 786	803
Tropical Africa						
Northern savanna subregion	3	1	4	0	4	18
West Africa	128	28	156	0	156	45
Central Africa	75	35	110	20	130	98
East Africa and islands	193	15	208	321	529	403
Developing tropical South Africa	0	30	30	57	87	5
Total	399	109	508	398	906	569
Developing temperate southern Africa	0	19	19	72	91	12
Total Developing Africa south of Sahara	399	128	527	470	997	581
Tropical Asia and Far East						
South Asia	458	209	667	62	729	1 542
Continental Southeast Asia	94	11	105	5	110	40
Insular Southeast Asia	778	45	823	123	946	465
Centraly planned tropical Asia	19	0	19	41	60	90
Oceania developing	19	2	21	34	55	—
Total	1 368	267	1 635	265	1 900	2 137
East Asia developing	0	183	183	809	992	1 680
Total Developing Asia and Far East	1 368	450	1 818	1 074	2 892	3 817
TOTAL TROPICAL COUNTRIES	1 915	1 165	3 080	1 623	4 703	3 267

* Not for wood-processing industries but rather for firewood, charcoal, protection forestry.

has a low population pressure, will lose less than 3 percent, from 170.6 million hectares in 1975 to 165.7 million in the year 2000. The decrease of operable closed hardwood forests is a matter of much concern for West Africa, with 12.1 million hectares down to 5.5 million — a loss of about 55 percent, and in East Africa down from 6.3 million hectares to 3.1 million — a decrease of about 50 percent. Because of the high population pressure in West Africa, there is a likelihood of development of intensive forest management in the much reduced productive forest estate; about 1.5 million hectares could thus be under intensive management by the year 2000.

The area of natural softwood forests was less than 1.9 million hectares in 1975, or 4 percent only of the world's tropical softwood forests. These forests are situated in East Africa, but 90 percent are inoperable because they are located on inaccessible land.

By the year 2000 they are expected to total 1.7 million hectares, a 9 percent loss. Depletion will be significant mainly in the operable part of these forests which will be reduced by 46 percent, from 370 000 to 200 000 hectares.

Industrial plantations. The total area of industrial plantations in tropical Africa in 1975 amounted to half of each of those existing in the two other tropical regions. Furthermore, 75 percent were low-yielding plantations. Fuelwood plantations, representing 39 percent of the total plantation area, are quite insufficiently developed in the northern savanna subregions and in West Africa.

By the year 2000 the total area of

Table 5. Estimated areas of industrial plantations at end of 1980
(Thousand hectares)

Regions/subregions		Hardwood			Softwood	Hardwood and softwood
		Low yielding	High yielding	Total		
Tropical America						
Central America		15	12	27	24	51
CARICOM		15	0	15	16	31
Other Caribbean		23	65	88	65	153
Tropical south Latin America		188	945	1 133	1 502	2 635
	Total	241	1 022	1 263	1 607	2 870
Temperate South America		88	261	349	909	1 258
Total Central and South America		329	1 283	1 612	2 516	4 128
Tropical Africa						
Northern savanna subregion		4	1	5	0	5
West Africa		168	50	218	20	238
Central Africa		78	50	128	31	159
East Africa and islands		199	16	215	453	668
Developing tropical southern Africa		0	30	30	57	87
	Total	449	147	596	561	1 157
Developing temperate southern Africa		0	19	19	72	91
Total Developing Africa south of Sahara		449	166	615	633	1 248
Tropical Asia and Far East						
South Asia		615	286	901	103	1 004
Continental Southeast Asia		121	19	140	7	147
Insular Southeast Asia		779	85	864	151	1 015
Centrally planned tropical Asia		94	5	99	106	205
Oceania developing		31	11	42	80	122
	Total	1 640	406	2 046	447	2 493
East Asia developing		0	273	273	953	1 226
Total Developing Asia and Far East		1 640	679	2 319	1 400	3 719
TOTAL TROPICAL COUNTRIES		2 330	1 575	3 905	2 615	6 520

industrial plantations is expected to be only 2.1 million hectares. Western Africa will not have compensated by far the loss of its natural forest resources and the subregion will be in a tight supply situation. The proportion of high-yielding plantations is expected to increase between 1975 and 2000.

Asia and the Far East

Natural forests. In the base year 1975, the total area of tropical hardwood forests for Asia and the Far East was 327 million hectares, or 19 percent of the world total, but as much as 89 percent of these forests were closed forests (26 percent of the world total), more than the corresponding figure for tropical Africa. However, because of the high proportion of inoperable closed forests — 35 percent — the percentage of operable forests compared to the tropical world is only 23 percent. This slight decrease is more than made up for by the high commercial value of these forests where the net yield in the form of commercial logs varies from 20 to 80 or more m^3 per ha — at least four times over what is being extracted per ha of forest in Africa and America. Intensively managed forests are relatively important: 42 million hectares out of 188 million of operable forests mainly located in India and Burma. There are also four million hectares of subtropical and temperate forests in insular China and the Republic of Korea, of which one third is unproductive or has only a protective value.

The total area of tropical closed hardwood forests of this region for the year 2000 has been estimated at 243 million hectares corresponding to a decrease of 48 million, or 17 percent. This loss is relatively more important

Table 6. Estimated areas of industrial plantations in the year 2000
(Thousand hectares)

Regions/subregions		Hardwood			Softwood	Hardwood and softwood
		Low yielding	High yielding	Total		
Tropical America						
Central America		50	50	100	130	230
CARICOM		20	0	20	50	70
Other Caribbean		45	100	145	140	285
Tropical south Latin America		615	3 655	4 270	3 165	7 435
	Total	730	3 805	4 535	3 485	8 020
Temperate South America		115	630	745	1 940	2 685
Total Central and South America		845	4 435	5 280	5 425	10 705
Tropical Africa						
Northern savanna subregion		10	—	10	0	10
West Africa		315	205	520	180	700
Central Africa		95	130	225	90	315
East Africa and islands		225	40	265	715	980
Developing tropical southern Africa		0	30	30	55	85
	Total	645	405	1 050	1 040	2 090
Developing temperate southern Africa		0	20	20	70	90
Total Developing Africa south of Sahara		645	425	1 070	1 110	2 180
Tropical Asia and Far East						
South Asia		1 330	690	2 020	640	2 660
Continental Southeast Asia		240	95	335	55	390
Insular Southeast Asia		795	525	1 320	515	1 835
Centrally planned tropical Asia		500	25	525	485	1 010
Oceania developing		75	50	125	260	385
	Total	2 940	1 385	4 325	1 955	6 280
East Asia developing		235	390	625	1 360	1 985
Total Developing Asia and Far East		3 175	1 775	4 950	3 315	8 265
TOTAL TROPICAL COUNTRIES		4 315	5 595	9 910	6 480	16 390

if we consider operable closed hardwood forests, since it will amount to about 24 percent. The subregions most affected are insular Southeast Asia and the Indian subcontinent. There will be progress in the intensive management of these forests but their total area will nevertheless contract because of expected encroachments.

During the same base year the total area covered by natural softwood forests was 11.9 million hectares or 26 percent of the world's tropical softwood forests to which must be added 2.8 million in insular China and the Republic of Korea. Seventy-three percent of this total was operable, with 3.5 million hectares or 40 percent being intensively managed.

A decrease of 1.2 million hectares is expected between 1975 and 2000, reducing the total area to 10.7 million hectares. This loss will mainly occur in the Indian subcontinent and to a lesser extent in the Indochinese peninsula.

Industrial plantations. The "tropical Asia and Far East" region has as many industrial plantations as tropical America, 1.9 million hectares, and the "East Asia developing" subregion as much as the "temperate South America" subregion. This similiarity of the two regions does not apply to the composition of industrial plantations, nor to the total amount of non-industrial plantations that is much more extensive in Asia and the Far East. Low-yielding hardwood plantations represent 72 percent of the total industrial plantations of this area, as against less than 8 percent in tropical America. South Asia and insular Southeast Asia — mainly Indonesia — are by far the most important tropical subregions for industrial and non-industrial plantations.

The considerable plantation effort of the Republic of Korea is also worth noting.

By the year 2000 the total area of industrial plantations will be multiplied by 3.3 in tropical Asia and the Far East as against a factor of 4.2 for tropical America and 2.3 only for tropical Africa. It is assumed that the proportion of low-yielding hardwood plantations will have decreased to 47 percent, which is still high. As for some parts of tropical Africa, some subregions will not have counterbalanced their loss of natural forest by equivalent plantation efforts.

The estimates and forecasts of areas of natural forests and industrial plantations in most developing countries served as one baseline for the assessment of net removals of industrial wood up to the year 2000. The classifications used were designed to fit the particular objectives of this study. Therefore more attention was given to the forest and plantation types producing industrial wood than to those providing only services and wood for non-industrial purposes. This is why there was no attempt to forecast the trends in areas of woodlands and of non-industrial plantations, although these two broad categories fill very important functions in many of these countries.

Drawing conclusions

These estimates are partial and limited, but they enable us to draw some conclusions:

1. To begin with, the overall figure for depletion of closed forests in the tropics — 140 million hectares in 25 years — appears less alarming than those generally quoted, such as the suggestion that net losses are 50 000 hectares every day. But that is not all. We should like to point out that:

- The present rate of deforestation should slow down, not so much because of improved land use in the future, but mainly because little pressure will be exerted on a "core" of tropical hardwood forests (north of the Amazon river, Congo basin), after most of the more inhabited part will have been converted to non-forest uses.
- The operable forests are much more prone to depletion than the permanently unproductive/inoperable ones which are on terrain not suited for agriculture. Furthermore, the proportion of undisturbed forests in the remaining operable forests will decrease while temporarily unproductive logged-over forests will represent an increasing part of them.
- The depletion of softwood forests is more serious in relative terms than that of closed hardwood forests, although less impressive in absolute terms.
- The depletion of open woodlands must be added to that of closed forests to get a global picture of the evolution of the tropical forest cover of the world. Although no precise assessment was done, a rapid review shows that this depletion should be larger than 70 million hectares between 1975 and 2000 — more than 33 million hectares in tropical America, more than 31 million in tropical Africa and more than 6 million in tropical Asia and the Far East. Furthermore, a slow degradation process will continue in many woodlands because of overexploitation, mainly for fuelwood and fires.

2. The total afforestation effort contemplated until 2000 is small compared to the total deforestation. But we must understand that this new afforestation is in addition to the replanting of logged-over plantations, and the reforestation of some natural forests and plantations for non-industrial purposes, such as fuelwood, charcoal and fruit trees.

> ... because agriculture, water regimes, the quality of life of man and animal depend heavily on maintaining natural forests, especially in the tropics.

3. Prospects for supply of industrial wood from the tropical countries were derived partly from this study of the resource base. Roughly speaking, the net removals by the year 2000 should be about two and a half times those of 1975. Although this is a significant increase, the combined effects of population and economic growth in tropical countries and the resultant expansion of local demand for forest products will result in a progressive reduction of their global export potential of tropical wood products and in aggravated local shortages. In addition, there is the critical problem of shortages of fuelwood in less forested areas.

More than wood

When looking at forest area statistics or discussing gains and losses in forest areas, two realities have to be kept in mind. One is that any given area of plantation forest is much more productive of industrial wood than an equal area of natural forest. The other is that the loss of natural forest means much more than an economic loss of wood. It means the transformation, damage, or loss of whole environmental systems, the disappearance of plant and wildlife species, the destruction of watersheds, the onset of erosion, the possible change of whole water regimes in valleys and lowlands. Management of forests is not simply about wood production, but about the state of health and productivity of the environment as a whole, including adjacent and even distant agricultural and urban areas.

This study showed that information on the present situation of tropical forest resources is generally inadequate at national as well as regional levels. There is a definite need to develop monitoring procedures for forest resources in most tropical countries. Simultaneously, information should be collected and compiled on a continuous basis at the regional and global levels. This is precisely what the Forestry Department of FAO is doing at present with the assistance of the United Nations Environment Programme and its Global Environmental Monitoring System. ■

The impact of the environmental era on forestry education in North America

J.E. DeSteiguer and

R.G. Merrifield

A generation ago forestry in North America had as its primary objective the management of the forest as a source of wood. Today the scope of forestry is broader and there is concern that the forest be managed in an environmentally acceptable manner for a broad range of goods and services.

The reasons for change are certainly of interest to forestry educators and we have all heard them — intellectual inquiry into natural resources, rising per caput income, increased leisure time, physical mobility, growing urban influence and widespread discovery of the outdoors by the populace (Beale, 1970). The resulting changes in the profession of forestry have not occurred in a vacuum, but rather because of greater social change.

Probably the most significant social phenomenon to have an impact on professional forestry curricula was the era of environmental concern which began in the early 1960s. Educators in a broad spectrum of fields began to capitalize on this wave by marketing a variety of courses and curricula in environmental fields. Enrolments in the natural resource profession began to soar, largely because of a new interest in environmental concerns. Students who ten years earlier might have majored in the liberal arts began a strong migration toward natural-resource curricula. This group included some very bright but not strongly career-oriented young people who added a new intellectual dimension to professional educational programmes. Forestry schools moved rather deliberately into this emerging market. Forestry as such was sufficiently environmentally oriented to attract a large number of majors as well as masses of students from other majors who were seeking electives with an environmental flavour.

The environmental emphasis in forestry schools assumed several forms. New courses were added to cover subjects not treated in existing courses or to provide service courses to students

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A CONTROVERSIAL CLEAR-CUT SITE IN THE AMERICAN NORTHWEST
disturbing to some, but to others a source of anger against environmentalists

from other fields. Regrettably and inevitably some courses of questionable value were offered simply to capture a portion of the new environmental market.

Modifications in the profession have affected the instruction of forestry. Non-traditional programmes reaching non-traditional audiences is the dominant topic of discussion at meetings of educators (Foil, 1978). Responding to the altered social environment, employers and students have called for a broadening of the instructional curricula. Even among educators, some have called for a discarding of the more vocational course offerings (Avery, 1967). The need has been voiced for environmental education.

To what degree have forestry curricula been broadened to include environmental education; and what is the future of forestry environmental education in North America? Insight into these questions was obtained through a questionnaire which was mailed to the North American colleges and universities offering professional forestry programmes. The purpose of this article is to present the salient findings of these questionnaires.

But, first of all, two terms must be clarified. One is environmental education. In recent years the word "environemnt," like the word "ecology," has been misused. Although frequently used they are rarely defined in the context of their usage. So then, what is "environmental education?" In an article on the subject they wrote for *American Forests* magazine in 1971, Schultz and Thompson implied that an environmental education is one in which the separate resource disciplines are integrated so that the professional forester will not be indifferent to the broad, overall environmental consequences of his forest management activities.

The second term requiring clarification is "forestry environmental course." For the questionnaire, a forestry environmental course was defined as one in which the primary learning emphasis is one or the following:

— The environmental impact of forest practices.
— The study of environmental law and policy related to forestry.
— Integrated resource or land-use planning.

Specifically excluded from this definition were forestry survey courses offered to non-forestry majors, and courses which have traditionally been a part of forestry curricula. One might rightfully contend that some traditional forestry courses, such as silvics, are environmental courses, but the purpose of the questionnaire and the definition was to isolate those environmental courses which have been offered to broaden traditional forestry curricula.

The questionnaires were mailed to 53 professional forestry schools in the United States and Canada. They were primarily aimed at determining

the extent of environmental course offerings, and plans for additional courses. The descriptive analysis presented here is based on the responses of 47 (89 percent) of the schools. For presentation of the data, five geographic regions have been designated: northeast, north-central, southern, western United States, and Canada. Additionally, the semester hour is the unit of measurement for the data presented in this study. In the North American educational system, the number of semester hours allocated to an individual college course represents the number of hours of instruction which the student receives in one week. For example, a three-semester-hour course is taught for three hours each week during the semester. A semester generally lasts 15 weeks, thus the typical three-semester-hour course involves about 45 hours of instruction.

Forty-two (89 percent) of the respondents indicated that they offered some type of environmental courses. Of the remainder that did not offer environmental courses, two were located in the north-central, and three were in the southern regions. Some of the schools began adding environmental courses as early as the 1950s, but most were initiated after 1965.

In both the United States and Canada, 1975 was the peak year for new environmental course offerings. The trend between 1965 and 1975 was one of increased semester hours of environmental courses offered each successive year. The exceptions were 1971 and 1973, when the number of new course hours fell below previous-year averages. Since 1975 semester hours of new environmental courses have steadily decreased.

Each of the five North American regions has a pattern of new environmental course offerings which is similar to the composite trend. There are, however, some notable regional differences. The northeastern region and Canada were the last to begin environmental courses. The north-central and western regions were the first to initiate these courses, and both show a relatively stable trend of new course offerings in each year. The southern region has had, possibly, the most erratic trend of new course offerings over the 14-year period. The trend of new environmental course offerings bears an interesting similarity to recent annual total enrolment in US forestry schools (Flinchum, 1978). Enrolment continued to climb during the early 1970s, reaching a peak of 22 345 in 1975. In recent years the enrollment, like new environmental course offerings, has begun to decline.

The typical North American forestry school offers an average of 20 semester hours of environmental courses. Fourteen of these hours are electives for both undergraduate and graduate students: six hours are required. Thus, the curricula have been broadened through the introduction of environmental courses, but in a manner which makes most of the courses optional for the student. The data also indicate that environmental courses are emphasized at the undergraduate, rather than the graduate, level. Twelve semester hours of these courses are offered to undergraduates, while only

> Educators began to capitalize on the new wave by marketing a variety of courses and curricula on the environment. Some courses of questionable value were offered simply to capture the new market.

How much attention is being given to the environment?

Average semester hours per school of environmental courses offered by forestry schools in the United States and Canada in 1978.

Region	Average semester hours per school			
	Undergraduate		Graduate	
	Required	Elective	Required	Elective
US	3	12	1	12
US	7	8	5	8
US	1	7	0	7
US	5	6	3	3
Canada	4	7	0	0
US and Canada	4	8	2	6

United States regions include schools that responded to the survey as follows:
Northeastern: Maine, Penn State, Rutgers, State University of New York, Vermont, Yale, West Virginia.
North-central: Illinois, Iowa State, Michigan, Michigan Tech., Minnesota, Missouri, Ohio State, Purdue, Southern Illinois, Wisconsin (Madison), Wisconsin (Stevens Point).
Southern: Clemson, Duke, Florida, Georgia, Kentucky, Louisiana State, Louisiana Tech., Mississippi State, North Carolina State, Oklahoma State, Stephen F. Austin, Tennessee, Texas A & M, V.P.I.
Western: University of California at Berkeley, Colorado State, Humboldt State, Idaho, Montana, Nevada, Northern Arizona, Oregon State, Utah State, Washington State.
Canada includes schools that responded to the survey as follows:
British Columbia, Lakehead, New Brunswick, Toronto.

IN A NORTH AMERICAN WOODLAND

How deeply rooted is environmental consciousness in young foresters?

eight hours are available to graduate students.

Although the typical school offers an average of 20 semester hours of environmental courses, individual school totals can vary markedly. As previously noted, five of the schools offer no environmental courses, but, at the other extreme, one school in the north-central region offers 104 semester hours of environmental courses, the greatest total for any school. The school with the second largest total is located in the southern region and offers 74 hours of environmental courses.

Regionally, the north-central and northeastern regions offer the most semester hours of environmental courses, each with an average of 28 per school. Western-region schools offer 17 hours, a considerably lower average per school than the two northern regions. Southern-region schools have an average of 15 semester hours of environmental courses, the lowest for any of the US regions. The Canadian schools average 11 semester hours, all at the undergraduate level.

Many of the schools reported that environmental courses enhanced the employment opportunities of their students. However, relationships between the regional course offerings and the principal types of employers are difficult to establish. For example, the southern-region schools depend primarily upon forest industry as an employer of their students (Robie, 1978), and these schools offer the fewest semester hours of environmental courses. In contrast, the western schools offer the second fewest course hours, and they depend heavily upon public forestry as an employer of their students. A similar inconsistency is found between the northeastern and north-central regions. Both regions offer an average of 28 hours of environmental courses, but the northeast looks to private industry as a principal employer, while the public sector is the primary employer for the north-central region.

The reason most frequently mentioned for the addition of environmental courses was that these courses were essential to a complete forestry education. This reason was cited by more than 50 percent of the respondents. Some qualified that response, stating that recently there had been greater inducement to furnish their graduates with a more complete understanding of the environmental impacts of forest management practices, and that this inducement had come from a variety of sources, most of which were outside the forestry school. Some of the sources mentioned were potential stu-

dents, legislators and employers.

The titles of the environmental courses indicate that they cover a broad spectrum of subject matter. For example, some deal with specific quantitative approaches to solving environmental problems, while others discuss the philosophy of environmental protection. The geographic scope of the courses also varies. Some courses deal with the environmental impacts of forestry within a single state, while others address the question of world resource management. Many of the courses focus on the physical effects of environmental degradation, and some extend this to include economic, social and political considerations. The great variety of course offerings indicates, to some degree, a searching on the part of forestry educators to determine the appropriate elements of environmental education.

Twenty-three of the schools (nearly 50 percent) offer a degree or option in environmental management, conservation of natural resources, or some related field. The purpose of these degree programmes is to provide the student with an environmental perspective which extends beyond traditional timber management. Some respondents noted that the generalist nature of these degrees may limit the employment potential of the students who receive them. As one forestry dean noted, most of his students with the generalist degree found work in non-professional jobs.

Thus, in summary, the data indicate that professional forestry schools in North America have attempted to broaden traditional forest management curricula through the introduction of environmental courses and degree programmes. Most new courses were initiated during the late 1960s and early 1970s. Recent years have shown a decline in the number of new courses offered. The schools in the north-central and northeastern regions offer considerably more environmental courses than the schools in the western and southern regions, and Canada. More environmental course hours are offered to undergraduates than to graduate students, and most of the courses are electives.

When asked about future environmental course offerings, 65 percent of the respondents stated that they expected the current number of courses to remain relatively stable, 24 percent expected an increase, while the remaining 11 percent could foresee a decrease. The differing responses were spread randomly about the five geographic subdivisions.

The rapid expansion of environmental course offerings seems to have ended in North American forestry schools. But the environmental era has probably made a permanent mark on forestry education.

The majority group cited a number of reasons for expected stability in the number of present course offerings. Some of the reasons were based on practical considerations such as burgeoning student enrolment, or a limited number of faculty. Many, however, felt as though the "environmental era" had peaked, and there would be less future pressure to expand environmental course offerings. Some stated that students had become more vocationally oriented and wanted to return to the traditional forestry core courses. This group also feels that new material can be incorporated into existing courses. The group that predicted an increase in future course offerings also cited several reasons for their opinions. Among these reasons were the need to enhance the student's appreciation of environmental matters, outside pressure to increase environmental teaching, and a need to increase the employment opportunities of their students.

The minority group which envisions a decrease in environmental courses restated many of the same views held by the group that predicts stability. The reason most frequently given by the minority group for decreasing course offerings was that the peak interest in the environment had passed. Some stated that the need for environmental courses indicated improper instruction in the traditional forestry courses. One respondent also mentioned the occurrence of what might be termed an "environmental backlash" on the part of students and faculty as they examine the social and economic trade-offs which result from extreme environmental pressures.

It appears as though the period of rapid expansion of environmental course offerings has ended for the North American forestry schools. Without question, however, the environmental era of the 1960s and 1970s has left a permanent mark on forestry education. New courses have been introduced and old courses have been modified to deal with the questions of environmental quality. No doubt there remains much to be done in the area of environmental education, but future change will likely come about in the framework of existing curricula. ■

References

Avery, T.E. 1967. Changing patterns in forestry education. *J. Forestry*, 65 (1): 34-35.

Beale, John A. 1970. Forestry in the environmental decade. *J. Forestry*, 68 (10): 639-641.

Flinchum, E. Mitchell. 1978. 1977 enrollment and degrees in forestry. *J. Forestry*, 76 (6): 358-359.

Foil, R. Rodney. 1978. The university environment and forestry education. *J. Forestry*, 76 (5): 281-283.

Schultz, A. Jay and William P. Thompson. 1971. A new era in environmental education. *American Forests*, 77 (4): 28-31.

Stoltenberg, Carl H. 1969. Forestry education: opportunities for innovation. *J. Forestry*, 67 (12): 876-877.

Robie, Edward F. 1978. Employment of 1977 forestry graduates. *J. Forestry*, 76 (6): 355-357.

Energy derived from wood in Europe, the USSR and North America

Kit Prins

Man's first use for wood was as fuelwood, and this remains the major use for it in most of the world. The change from a wood-energy economy to a coal-energy economy occurred first in Britain at the end of the sixteenth century, caused by the inability of wood supply to meet the rising demand for energy (mainly for iron- and glassworks and brick kilns) and the easy availability of coal as a substitute fuel. It may be of interest for today's energy forecasters to note that this radical change was accomplished in a relatively short time — perhaps thirty to fifty years — and with considerable economic and social disruption, including steep rises in the price of fuelwood (Dwyer, 1976).

Since this first shift away from a wood-based energy economy, fuelwood's advantages — renewability, simplicity of harvesting and combustion — have been outweighed by its disadvantages — low ratio of calorific value to volume, which increases handling costs, and lack of convenience for large-scale automated boilers. But the main disadvantage of wood is that the supply of fuelwood is not up to the world's growing demand for energy.

A rise in the relative prices of purchased energy as foreseen by many forecasters might have some of the following consequences for the forest industries:

- Higher production and a rise in the share of production costs taken by energy — such a change could take place fairly rapidly.

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- The implementation of further energy conservation measures, and greater importance given to energy conservation criteria in investment decisions.

- Reappraisal of the economics of using wood, including industrial wood residues, as a source of energy with possible effects on raw material availability for the manufacture of pulp, particle board and fibreboard.

- Modifications in the competitive position of different forest products and of alternative materials according to their energy intensity.

At the present stage of knowledge on energy consumption patterns of the forest industries, it is not possible to quantify with any degree of accuracy to what extent any of these consequences will occur or to attempt any forecasts.

We hope that further information will become available, thus affording a better analysis of an aspect of the forest industries which, until very recently, has been neglected at least in the mechanical wood-processing sector.

In order to provide a basis for planning and executing such measures, interested countries should strengthen considerably these data bases, notably by collecting comparable data for all sources of energy, including wood-based fuels, and by providing information for the forest industries at the individual product level.

This study aims to estimate the quantity of energy derived from wood at present; to find out how this energy is used; also, to examine the consequences for the forest industries of an increase in the use of wood as a source of energy and to identify some of the factors which might cause such an increase.

No attempt is made to examine the "unconventional" wood/energy systems which have recently been proposed (manufacture of liquid or gaseous fuels, energy plantations, etc.), which are being examined elsewhere in the United Nations Economic Commission for Europe (ECE). Readers are referred to reports on the situation and prospects for wood-derived energy in Finland, Norway and Switzerland by Messrs Hakkila, Gislerud and Semadeni (TIM/SEM.7/R.18, 4 and 6 respectively) and to the assessment by Mr. Zerbe of the technical and economic potential for wood-derived fuels (TIM/SEM.7/R.15).

Most roundwood harvested specifically for fuel is used domestically on the farms or in the forests where it is harvested, mainly for space and water heating in rural areas. Large quantities are used without ever entering commercial channels and are not recorded statistically. Therefore, accuracy of data on fuelwood consumption is probably very low and we should not rely too much on the volumes shown, although these recorded developments probably reflect real trends fairly adequately.

The steady decline in fuelwood consumption in the ECE region over the last 25 years is apparent from Table 1. Over this period the decline was most marked in North America (—75 percent) and least marked in the USSR (—24 percent). In Europe fuelwood consumption was halved.

Has the "energy crisis" of 1973-74 and the consequent increased attention to energy questions affected fuelwood consumption? Table 2 shows that the decline in fuelwood consumption appears to have continued in Europe and the USSR, with temporary irregularities in 1975-76 for Europe and in 1974 for the USSR. In North America, however, consumption rose by 9 percent in 1976 and by 16 percent in 1977 (admittedly from a low base). Is this a passing trend or is it the first sign of a significant move back toward fuelwood in a region where many people are acutely aware of the ecological implications of their choice of fuel and where wood is easily available in rural areas? The fuelwood stove is a part of the "alternative life-style:" but will this change — this increase in the use of fuelwood — at the national level have any measurable impact on the wood economy? And if so, will the trend spread to Europe, at least to areas where the presence of both suitable wood and conditions can encourage its use? These questions cannot be answered after only two years of results and enthusiastic press reports. However, we must now give some considerations to these possibilities in any long-term assessment of prospects for the timber economy and for energy supplies.

The forest industries also derive part of their energy from solid wood residues and bark and from pulping liquors. For our study we assumed that half the residues not used as raw materials were used for energy. Conversion factors presented in an OECD study were used to estimate the amount of energy derived from pulping liquors. On the basis of the recorded statistics for fuelwood and the above assumptions, the quantity of energy derived from wood may be estimated as in Table 3.

Thus wood accounted for 1.4 percent of total energy consumption in Europe, 1.2 percent in North America and 2.6 percent in the USSR. This relatively small percentage is, however, not an adequate reflection of the importance of wood as a source of energy for rural communities and forest industries.

On the reasonable assumption that most fuelwood is used domestically or on farms and that all wood residues and pulping liquors provide energy for industrial purposes, we may make the following breakdown of the use of wood for energy (in percent of total energy derived from wood):

	Domestic/rural	Industrial
	.... *Percent*	
Europe	56	44
North America	17	83
USSR	77	23
ECE region	51	49

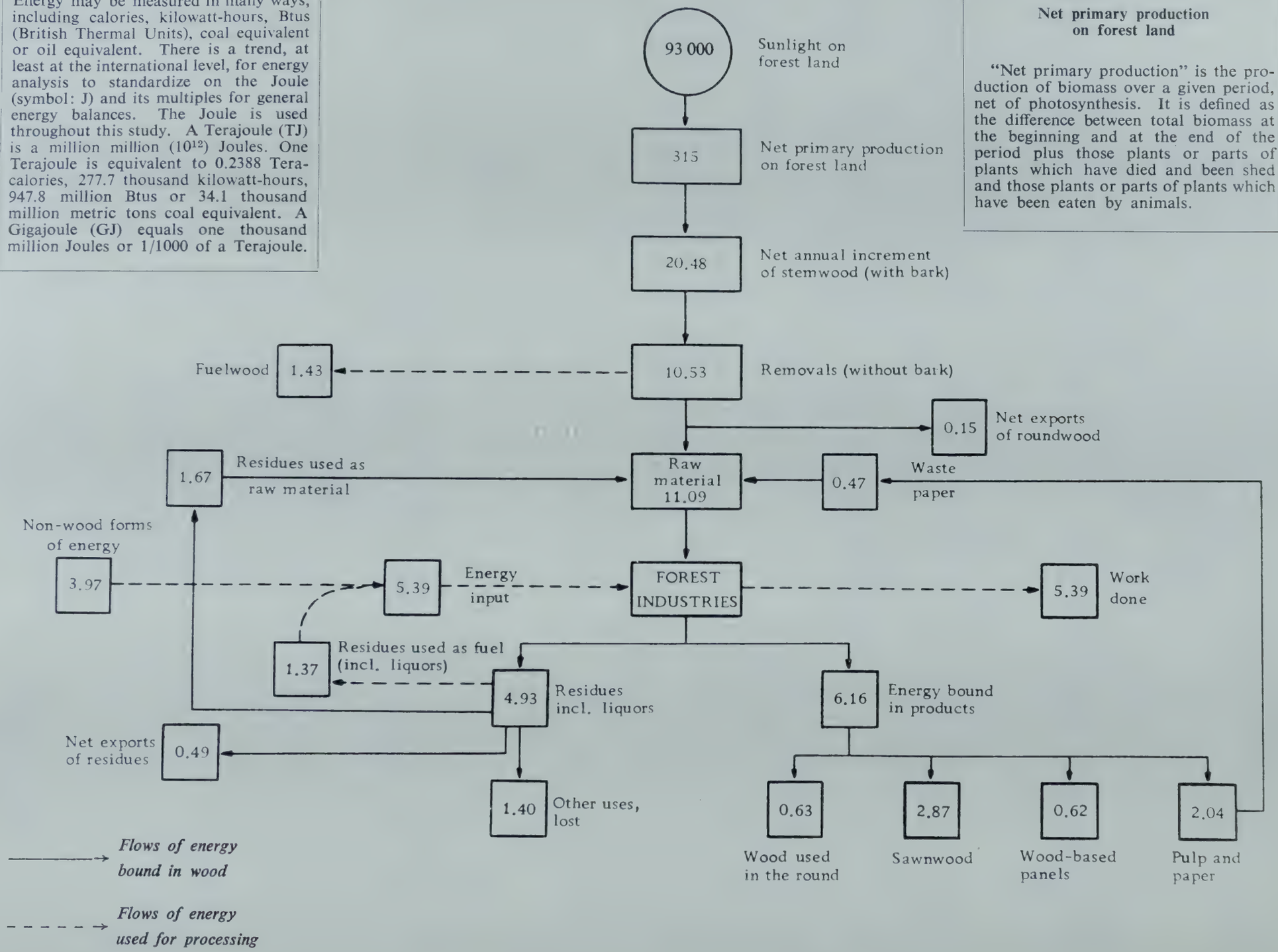
The contrast in the distribution of uses between the different regions is striking. In North America, wood-

Figure 1. ECE region: energy flows in the forest industries in the mid-1970s (10^6 TJ)

Energy may be measured in many ways, including calories, kilowatt-hours, Btus (British Thermal Units), coal equivalent or oil equivalent. There is a trend, at least at the international level, for energy analysis to standardize on the Joule (symbol: J) and its multiples for general energy balances. The Joule is used throughout this study. A Terajoule (TJ) is a million million (10^{12}) Joules. One Terajoule is equivalent to 0.2388 Teracalories, 277.7 thousand kilowatt-hours, 947.8 million Btus or 34.1 thousand million metric tons coal equivalent. A Gigajoule (GJ) equals one thousand million Joules or 1/1000 of a Terajoule.

Net primary production on forest land

"Net primary production" is the production of biomass over a given period, net of photosynthesis. It is defined as the difference between total biomass at the beginning and at the end of the period plus those plants or parts of plants which have died and been shed and those plants or parts of plants which have been eaten by animals.



derived energy is predominantly industrial: in fact over 70 percent is in the form of pulping liquors, and energy from fuelwood or solid wood residues has dwindled to negligible proportions (although these sources appear to be making a comeback). In the USSR on the other hand, more than three quarters of wood-derived energy came from fuelwood, an easily available energy source for human settlements in remote regions such as, for example, Siberia, where fossil fuels such as oil or coal are difficult and expensive to obtain. Furthermore, in relation to the total economy of the country, the chemical pulp industry in the USSR is relatively little developed. In Europe (excluding the USSR), about half of wood-derived energy is from fuelwood, used in remote areas (such as parts of Scandinavia and Finland, mountain valleys, parts of southern and eastern Europe) and half from wood residues and pulping liquors, consumed by the region's forest industries. The even distribution between rural/domestic and industrial uses at the level of the ECE region results from the combination of these trends.

Figure 1 shows, in energy terms, the flow of raw materials and energy in the forest industries sector of the ECE region in the mid-1970s (where possible the data are averages for 1974-76). From the net annual increment stage onward, the chart is based on ECE/FAO Agriculture and Timber Committee statistics and on the estimates of the two secretariat papers.

The sunlight and net primary production figures were calculated from values given in the current literature of quantitative ecology for the latitudes and major vegetational types represented by the forest lands of the ECE countries. For the sake of completeness, some flows have been calculated as residuals, and particular items missing for certain subregions have been estimated on the basis of partial or unofficial information. It has also been necessary to omit certain factors for lack of information (energy used in harvesting and transport, bark, natural losses, logging residues, energy contained in glues and other additives, etc.).

Table 1. ECE region: consumption of fuelwood 1949-51 to 1974-76

	Volume consumed				Annual average change		
	1949-51 (av.)	1959-61 (av.)	1969-71 (av.)	1974-76 (av.)	1949-51 to 1959-61	1959-61 to 1969-71	1969-71 to 1974-76
	Million m³				*Percent*		
Europe	121.8	93.6	68.4	56.3	—2.6	—3.1	—3.8
North America	69.9	50.9	20.7	17.9	—3.1	—8.6	—2.9
USSR	111.6	111.1	86.9	84.8	—	—2.4	—0.5
ECE region	303.3	255.6	176.0	159.0	—1.7	—3.6	—2.1

Table 2. ECE region: consumption of fuelwood, 1973 to 1977

	1969-71 (av.)	1973	1974	1975	1976	1977
	Million m³					
Europe	68.4	58.8	54.0	54.9	56.0	54.0
N. America	20.7	17.6	17.6	17.2	18.8	21.7
USSR	86.9	83.5	84.8	82.2	81.6	74.0
ECE region	176.0	159.9	156.4	154.3	156.4	146.1

Table 3. ECE region: energy derived from wood compared to total energy consumption

	Fuelwood	Residues	Pulping liquors	Total	Total energy consumption
	Thousand TJ				
Europe	505	110	280	895	61 761
N. America	160	105	650	915	77 531
USSR	765	[1]135	90	990	38 656
ECE region	1 430	350	1 020	2 800	177 948

[1] Estimated that 15 percent of total available residues used as fuel.

With reference to assessing potentials for solar power in general, and biomass in particular, we should note the great step down from incident solar radiation to net primary production (see Figure 1). Nevertheless, forests remain one of the most efficient means for capturing solar energy, and particularly for storing it semi-permanently. Increasingly widespread recognition of this fact is responsible for the current interest in the possibilities of "energy plantations" among national energy planners as well as foresters.

On the basis of the estimates made above, it is possible to make a summary evaluation of the place of wood as a source of energy.

On the national or regional level, wood is not an important direct source of energy. The three types of wood-derived energy mentioned in Table 3 accounted for about 1.5 percent of consumption of energy in the mid-1970s, both in Europe and the ECE region as a whole. The relative importance of the forest in energy terms would appear greater if substitution effects were taken into account by

comparing net energy input for wood-derived products with net energy input to non-wood products performing the same function. In fact, biological synthesis of the wood itself is a (solar) energy-intensive process, comparable in some ways to industrial synthesis of substitutes.

The size and nature of the resource will not permit wood to be a major annual source of energy on the scale of oil, coal or gas without changes of unprecedented magnitude or without severely depleting the resource. To take an extreme example, even the total net annual increment of stemwood of about 2 275 million m^3 with bark in the ECE region is equivalent, in energy terms, to little more than 10 percent of its energy consumption. It is thus fair to say that, without really far-reaching measures such as the allocation of large areas of fertile land to "energy plantations" and with the possible exception of certain forest-rich areas, wood cannot be more than a supplementary source of energy for the ECE region.

Although marginal in terms of annual fuel requirements, the forest is a renewable resource, which gives it some advantages over other, depletable resources in the longer term. Thus, if the composition and productivity of the forests in the ECE region were only to remain constant over the next 50 years (a period chosen as the generally agreed maximum endurance of reserves of oil and gas), the energy equivalent of the cumulative increment of stemwood would be slightly more than 1 t $\times$ 10^9 TJ (Terajoules — see chart): this is equivalent to almost half the region's recoverable reserves of oil and gas, estimated by the World Energy Conference (Istanbul, 1978), slightly modified for North America, at 2.2 t $\times$ 10^9 TJ, and about 15 percent of world reserves of these fuels, estimated a 7t $\times$ 10^9 TJ. This comparison does bring out the sometimes underestimated long-term potential of small flows from a renewable resource, compared with a supply from a large, non-renewable one.

The generation of energy remains, however, an important end use for wood. An unexpected fact which appears from the estimates in Table 3 is that about one quarter of all the wood removed from the ECE forests is ultimately used as a source of energy. In fact, the amount of wood which is burned appears to be roughly equivalent to the volume of sawnwood produced in the region, slightly larger than the volume of fibre, including waste paper, contained in pulp and paper, and considerably larger than the wood in wood-based panels. Although it must be stressed that these proportions are based on estimates, notably as regards the importance of pulping liquors, they should lead those concerned with policies in the forest sector to examine more closely their importance as an end use for wood. The conclusion must be that even in the developed world, the use of wood for the generation of energy has not been small, although its importance has declined. Furthermore, indications are that as policy-makers devote increasing attention to energy supplies, looking for renewable sources to replace fossil fuels, this use for wood will grow in importance.

Without far-reaching measures such as allocation of large areas of fertile land to "energy plantations", and with the exception of certain forest-rich regions, wood cannot become more than a supplementary source of energy for Europe, the USSR and North America.

For the forest industries, however, wood is an important source of energy. Waste liquors alone account for over 20 percent of energy input to the pulp and paper industries of the region and liquors and solid wood residues together for over 25 percent of energy input to the forest industries as a whole.

Some sectors of the forest industries are in theory self-sufficient or even net providers of energy. Increased use of wood as a source of energy could make the forest industries in general and sawmills in particular more self-sufficient in energy. Indeed the energy value of the residues created by sawmills, plywood mills, and veener mills, about 550 thousand GJ (Gigajoules — see Figure 1), is about 2.5 times as much as the energy consumption of the mechanical wood-processing sector, about 210 thousand GJ (which includes the manufacture of particle board and fibreboard, which do not generate solid wood residues in large quantities). However, this self-sufficiency is at present almost entirely theoretical: we saw that wood is at present a minor source of energy for the mechanical wood-processing sector. Also most of the residues "available" for use as energy are in those areas where the forest industries are less intensively developed, and where at present a large proportion of residues generated is probably lost. Species also plays an important role: hardwood residues which are less suitable for use as raw material are therefore more readily available as a source of energy. This is currently being demonstrated in the United States.

Those areas with large mechanical wood-processing sectors, which need important quantities of energy, are naturally those where the intensive use of residues for raw material is most highly developed, correspondingly reducing the availability of residues as a source of energy. Nevertheless, in purely quantitative terms, enough energy could be generated from the residues of sawsmills, plywood mills and veneer mills to satisfy the needs of the mechanical wood-processing sector. For some sectors, difficulties may arise from the fact that energy is frequently needed in the form of electricity which it may be impractical or uneconomic to generate from wood residues at the mill — particularly in small-scale operations.

The possibility and economic desirability of using more wood residues to produce energy in any one case depend on a wide range of factors, including the following:

- Type and quantity of energy required (high- or low-pressure steam, electricity, space heating, etc.).

- Type, quantity and condition of residues available (moisture content, proportion of bark, sander dust, planer shavings, etc.).

- Energy equipment already installed and cost of different types of new equipment.

- Cost of non-wood energy and possible developments during the lifetime of equipment installed.

- Desirability of energy self-sufficiency for the plant (risk of interruption of external energy supplies).

- The costs and/or benefits of other possible destinations for residues (e.g., sale for use as raw material, in-plant transfer, disposal).

The combination of those factors will lead to different decisions in different circumstances although rising costs of energy will probably increase the proportion of residues being used for energy, with possible consequences for the raw material supply of the pulpwood-using industries.

A significant increase in the use of wood residues as a source of energy, caused by a rise in the relative price of energy, could have consequences for the whole of the forest and forest industries sector. The first consequence would be a further decline in the porportion of residues left unused, although, as mentioned earlier, the reserve of unused residues is already relatively limited in some parts of the region.

In a situation of continued expansion of demand for the products of pulpwood, that is, if final demand is not seriously affected by higher prices for energy, the following is envisaged:

Competition for the available residues between demand for raw material and demand for energy could raise their price and increase demand for alternative types of wood raw material. This in turn could increase the availability of wood raw material from sources currently less exploited for economic or technical reasons (whole-tree logging, silvicultural thinnings, round pulpwood in areas where harvesting costs have so far discouraged exploitation). Higher prices for pulpwood could also divert some wood from the sawnwood to the pulpwood sector, either by pulping of small sawlogs or by reducing yields of sawnwood. The recovery of waste paper could also be encouraged.

In these circumstances, overall raw material costs for the pulpwood-using industries would increase. The interrelationship of the factors concerned is, however, very complex and varies widely between different areas and industries. Further analysis, in both qualitative and quantitative terms, is therefore necessary before the full implications of a rise in energy prices for the forest and forest industries sector are fully understood.

It has been suggested that the following potential sources of wood energy be developed as part of an effort to increase the share of renewable sources of energy and thus reduce pressure on reserves of depletable fuels: silvicultural thinnings; logging residues (including branches, tops, etc., harvested as part of full-tree or full-stem logging); "energy plantations" of quick-growing trees or shrubs, cultivated exclusively as a source of biomass energy.

Several countries have been examining the technical and economic feasibility of developing these sources of energy, either by direct combustion or for the manufacture of liquid or gaseous fuels, as well as the implications of such development on the forest sector. For example, they are looking into the possibility of catching up on thinning regimes which have fallen behind what is silviculturally desirable; competition for logging residues between the energy sector and the pulpwood-using sector; need for more mechanized harvesting systems and different silvicultural practices, including the choice of different species.

This study has attempted to describe briefly the present situation, and past trends, regarding energy consumption by the forest industries and energy derived from wood, and to explore possible energy conservation measures and consequences of a rise in energy prices. To summarize, here are the main ways through which these industries can participate in energy conservation at the national or regional level:

- Technical improvement of production processes (using less energy to do the same job). The pulp and paper sector has a record of success in this field.

- Ensuring that no combustible residues are unused or burned without recovery of the energy. In future, more favourable economies could encourage the industries even to burn those residues which are at present a source of raw material with consequences which are difficult to foresee.

- Encouragement of products that are less energy intensive. Little work has been done on this at present because of the complexity of the calculations involved. Not only should most energy used in manufacture be appraised, but also the characteristics of each product in use must be examined. Forest products appear less energy intensive than most other building products. It may be that energy conservation in construction could be encouraged by higher consumption of forest products, in place of other construction materials such as concrete or steel.

Unfortunately, however, the quality and quantity of the data on which this article is are founded leave much to be desired. The major conclusion to be drawn is all too familiar: the need for further investigation. Only then can a policy be formulated on a basis of sound knowledge and analysis.

References

DWYER, ALAN D. Wood and coal: a change of fuel. *History Today*, September, 1976.

OECD. *Energy profile and opportunities for savings in the pulp and paper industry*. DSTI/IND/PP/7802.

See also HANNON *et al.* Energy and Labor in Construction Sector. *Science*, 24, November 1978.

The new international market for game meat

Wolfgang Krostitz

Game, one of man's main sources of food and virtually his sole source of meat in prehistoric times, has over millennia of civilization and agricultural development ceased to be an important source of meat in most parts of the world. But now it seems that certain species of game animals are about to stage a comeback, though under conditions of partial or full domestication.

Today the contribution of game to total world meat production and consumption is very small and it is even smaller in the international meat trade. Accurate statistical information is grossly lacking. In many countries even statistical data on conventional meats produced by agriculture leave much to be desired, so the situation can only be worse in the field of game meat. Data on game animals killed are recorded in only a few countries with stringent hunting legislation (e.g., as the United States) and some countries in central and northern Europe. Estimates for other countries, if at all available, are based on food consumption surveys. Frequently, data on game meat output, consumption and trade are just included under "other meats" or "meats not elsewhere specified", together with meats produced by minor domestic animals or offals, or with "meats" from rodents, reptiles, snails, amphibious animals, marine mammals or even insects. For some important game-consuming countries, such as Canada and South Africa, no estimates are available at all, although it is well known that game meat is popular there.

FAO's Interlinked Computer System now contains estimates of game meat production for human consumption from some 50 countries. Although FAO statistics in this field are on the whole very crude and by no means complete, they do at least indicate an order of magnitude. Aggregate national estimates of annual game meat output amount to some 0.75 million tons, or as little as 0.5 percent of total world meat production, which will reach about 135 million tons in 1979. Even assuming that of the 1.5 million tons of "meat not elsewhere specified" indicated by the Interlinked Computer System, a significant portion is game, the share of game meat in total world meat supply remains very small.

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The developed countries account for about 40 percent of the estimated "world" output of game meat. The United States is the leading recorded producer, probably, as noted, because the numbers of animals shot by hunters are well recorded there. Virtually all of this game is consumed by hunters and not sold. With the main exception of Scandinavian countries, the proportion of game to total meat production is insignificant. On the contrary, in several developing countries, especially in tropical and southern Africa, game contributes substantially to the total supply of animal products. In countries such as Botswana or Zaire most of the meat produced and consumed is, actually, game. On the whole, the developing countries, who produce only one third of the world's output of conventional meats,

Table 1. Meat production in developing and developed countries in 1978

	Developing countries	Developed countries	World total
	Million metric tons		
Total meat	*45.7*	*86.7*	*132.4*
of which:			
Bovine	14.8	33.3	48.1
Pig	18.4	30.3	48.7
Poultry	7.5	17.9	25.4
Sheep and goat	3.9	3.4	7.3
Horse and similar	0.3	0.4	0.7
Game	0.4	0.3	0.7
Meat not elsewhere specified	0.4	1.1	1.5

account for some 60 percent of the world total in the case of game meat, with Africa by far the most important producing region. It is worth noting that in West Africa generally the meat of wildlife — "bushmeat" — fetches much higher prices in urban markets than beef, mutton, pork, goat or other domestic meat.

In the developing as well as the developed countries most of the game is consumed close to the place of hunting. Some efforts have been made to organize "harvesting" and marketing of game meat with transport over longer distances. To a growing extent marketing has also been through international trade. According to FAO statistics since the mid-1960s, world imports of game meat have nearly trebled, reaching some 55 000 tons in 1978, valued at about US$140

A GAME CROPPING SCHEME IN THE CAMEROON

developing countries are inclined to take game utilization projects seriously

Table 2. Estimated game meat output and per caput supply in selected countries in 1977

	Output	Per caput supply
	Thousand metric tons	*Kg*
Developing countries	426	...
Afghanistan	9	0.5
Angola	6	0.9
Argentina	39	1.0
Botswana	6	7.5
Cameroon	4	0.6
Chad	3	0.7
Congo	6	4.0
Benin	6	1.9
Ethiopia	7	0.2
Gambia	1	1.8
Ghana	28	2.7
Guinea	4	0.8
Iran	14	0.4
Ivory Coast	13	2.5
Kenya	7	0.5
Lesotho	4	2.9
Liberia	5	3.0
Namibia	2	2.6
Nigeria	95	1.2
Papua New Guinea	15	5.2
Rwanda	6	1.3
Sudan	7	0.3
Tanzania	8	0.5
Togo	4	1.7
Uganda	14	1.2
Zaire	68	2.6
Zambia	20	3.7
Developed countries	327	...
United States	240	1.1
Germany, FR	22	0.6
Sweden	8	1.1
New Zealand	5	0.3
Australia	14	0.9
United Kingdom	4	0.0
Finland	2	0.4

Source: FAO Interlinked Computer System

million. Thus about 7 percent of total game output enters international trade, a proportion slightly higher than for meat as a whole but the absolute quantity is still less than 0.5 percent of total world trade in meat products.

Developed countries in Western Europe account for the bulk of total recorded imports of game meat, with the Federal Republic of Germany and France being the largest buyers. Since the mid-1960s, imports by France have more than trebled and those of the Federal Republic of Germany doubled. Other heavy importers are Belgium, Italy, the Netherlands, Sweden and the United States, the only major importer outside Western Europe.

Argentina has traditionally been the largest exporter of game, supplying mainly hares to Western Europe. While its exports have shown substantial year-by-year fluctuations, the longer-term trend has been stationary. Exports of other developing countries are small. Among the developed countries, the United Kingdom has been the main exporter in recent years. Other important suppliers are New Zealand, Austria, Hungary, Poland and Yugoslavia, that is, countries which are also important exporters of conventional meats (see Table 3).

However, while exports of most suppliers consist mainly of game hunted according to traditional methods, an increasing part of supplies from New Zealand comes from farming of game

Table 3. International trade in game meat

	1966-70 average	1971-75 average	1976	1977	1978
	..... *Metric tons*				
Importers					
Germany, FR	11 015	16 002	20 091	18 755	19 094
France	7 446	12 879	17 120	18 225	16 972
Belgium-Luxembourg	2 135	5 093	7 420	8 784	7 571
Italy	1 808	2 306	1 674	2 603	2 481
Netherlands	785	1 261	1 527	2 181	2 284
Sweden	693	1 262	1 153	1 507	727
United States	1 051	1 205	1 109	705	1 787
Total	24 933	40 008	50 094	52 760	50 916
Others	321	1 426	787	1 044	1 039
GRAND TOTAL	25 254	41 434	50 881	53 804	51 955
Exporters					
Argentina	7 233	11 087	13 184	14 070	17 000
Poland	...	1 017	9 185	1 058	950
United Kingdom	...	...	6 249	8 224	8 149
Austria	2 260	2 847	3 967	4 352	2 857
New Zealand	3 096	4 192	2 836	4 121	3 965
France	552	3 710	2 680	2 837	3 039
Netherlands	921	1 739	2 197	1 838	1 492
Yugoslavia	628	624	1 074	885	1 061
Total	14 690	21 506	36 235	37 385	38 513
Others	1 993	7 659	3 796	5 725	3 003
GRAND TOTAL	16 683	29 165	40 031	43 110	41 516

Source: FAO Interlinked Computer System

animals, especially red and fallow deer. Farming of wildlife is also gaining importance in Australia, South Africa, some West European countries, the USSR and a few developing countries such as Kenya, Mauritius and Taiwan province, China.

Game meat exports from East European countries to West European markets, in particular to the Federal Republic of Germany, were well developed over the past twenty years in combination with the encouragement of foreign tourist hunting. Thus, East European deer, wild boar and pheasant have been earning foreign exchange twice over for a long time. The German (Fed. Rep.) hunter who pays a high fee for a hunting vacation in Hungary is allowed to bring home the antlers as a trophy. In the meantime, the meat, which belongs to the state, is exported, most likely to the Federal Republic of Germany.

New Zealand, now the forerunner of commercial deer farming, has some 30 000 red and fallow deer on close to 300 farms. With regard to venison exports, New Zealand is very careful to distinguish between "wild shot" and farmed venison. The former commands a higher price in the Federal Republic of Germany because of its allegedly better flavour. In Australia the number of deer kept for commercial purposes is about 5 000 animals, the majority being fallow deer.

Keeping deer in confinement in parks as a ready supply of meat has been a centuries-old custom in many parts of Europe, but recent developments in the same area have a much more commercial orientation. In Sweden, for example, about 100 farmers keep some 1 000 fallow and 2 000 red deer. In the United Kingdom (Scotland in particular) and the Federal Republic of Germany (Rhineland and Bavaria) research stations have been making considerable efforts to develop and promote commercial deer farming. As a consequence, interest among private producers is now growing rapidly.

This new interest in deer farming reflects rising demand not only for venison but also for by-products such as velvet antlers, skins, etc. In fact, in the USSR deer farming has been developed mainly for the export of velvet antlers to the Far East where they are used in traditional pharmacy as an aphrodisiac. Sales of these products are also of considerable importance to deer farmers in New Zealand and Australia where velvet antler currently fetches about Australian dollars 150 (US$170) per kg. Shooting fees may add to the income of owners of game animals. The price of an aphrodisiac capsule in a traditional Chinese pharmacy in Bangkok is the equivalent of US$2. Medical authorities in the west believe that aphrodisiacs from deer antler velvet owe their effect to psychological faith in them of those who buy them.

Venison is particularly popular in continental Europe and, in spite of its high price, demand has shown a considerable increase. In the main import market, the Federal Republic of Germany, current wholesale prices for best cuts of imported frozen red deer are above DM 20 (US$11) per kg or about the same as for beef fillet. For domestic fresh venison, producer prices at DM 12-15 (US$ 6.5-8) per kg carcass weight are about twice the level of beef or sheep meat. Nevertheless, game imports, at close to 20 000 tons in 1978, were about double those of ten years ago. In other markets where governments give less support to domestic prices for conventional meats than, for instance, in the EEC countries, venison fetches a substantial premium over prices of beef and lamb. This also applies to

ANTELOPE HUNTED FOR MEAT UNDER GOVERNMENT CONTROL

but seldom included in food statistics

prices in international trade (see Table 4).

Future prospects of demand for game meat as well as by-products appear to be rather good. For meat in general demand is still responsive to rising incomes even in countries where meat consumption levels are already high. Venison, because of its distinctive flavour and leanness — its fat content is significantly lower and its protein content higher than in most other meats — may actually benefit relatively more from rising purchasing power, notably in rich countries.

However, the growing interest in the farming of deer or other game does not only reflect rising economic demand for game meat and by-products, but also broader socio-economic and ecological considerations. While in Australasia levels of profitability well above those in conventional livestock production have provided the main impetus, in Western Europe general aspects of rural and environmental policy have been playing an important role. Because of continuing rapid technical progress in, and economic pressure on, traditional agriculture more and more marginal lands are being abandoned. At the same time, population is growing more slowly or even decreasing in some developed countries and output of several traditional agricultural products tends to exceed market outlets. The search for new ways of using marginal lands and improving employment opportunities in economically disadvantaged areas has in fact been behind efforts to develop deer farming, notably in the United Kingdom and the Federal Republic of Germany. More recently, Austria and Switzerland, whose agriculture are plagued by heavy dairy surplus problems as much as the EEC, have taken up the idea of developing deer farming as an alternative to traditional livestock production. Austria has actually been the first country to translate this concept into political action. As of April 1979 for a period of five years farmers in mountain areas will be granted an annual payment of Schilling 1 000 (approx. US$75) per dairy cow replaced by certain animals kept for purposes other than milk production.

Table 4. Prices of venison, lamb and beef in international trade
(US $/metric ton)

Annual average	Venison, New Zealand, c.i.f. Germany, FR	Lamb, New Zealand, London, (Smithfield)	Beef, Australia, c.i.f. USA
1973	3 050	1 390	1 892
1974	2 790	1 415	1 440
1975	3 220	1 475	1 202
1976	4 050	1 585	1 475
1977	4 430	1 695	1 385
1978	4 317	2 130	2 020
1979 (first quarter)	4 669	2 210	2 857

Under this scheme fallow deer qualify at a rate of ten deer per one dairy cow replaced. With regard to developing countries, the Government of Mauritius recently stated that deer, originally introduced from Java, has become an integral part of meat production, well adapted to land unsuitable for other uses, with output to be increased by more integrated management of forests for both timber and venison production.

This growing interest in deer farming has pushed up prices for breeding stock. In West Germany prices reached DM 1 200 to 1 500 (US$650-800) in early 1979 compared with less than DM 500 in 1976. Current prices for breeding fallow deer are about half the level for breeding cattle (which are about ten times heavier). In Australia at the end of 1978 prices were as high as A$500 (US$565) for rusa deer and A$1 000 (US$1 130) for red deer. Deer breeders in Australia are optimistic about further expansion of this new sector of the livestock industry; though production of game meat is expected to be primarily for domestic consumption, there should be growing exports of by-products.

Additional production in New Zealand will probably be mostly for export. There are optimists who believe that within the next decade or so the commercial deer population in New Zealand could approach half a million. This would still be small compared with New Zealand's sheep and cattle population of about 60 and 9 million respectively. In any case, the share of the deer industry in the country's total export earnings should grow from its present level of 1 percent.

Exportation of game meat is facilitated by relatively liberal import policies of the major meat-importing countries. This happens although by and large the same animal health regulations apply to game as to other meats, restricting and in some cases ruling out altogether imports of meat or of certain types of meat from exporting countries not free of major animal diseases. In the EEC, the largest market, game is subject to a tariff duty of only 5 percent while the duty on sheep meat is 20 percent and imports of beef, pig and poultry meat are severely restricted by a variable levy system. There are also prospects for rising import demand in other developed countries and perhaps some of the richer developing meat-importing countries.

But we should keep in mind that if domestic production is successfully promoted in some major consuming countries, a rapid expansion of production for export by New Zealand and other countries might in the longer run result in lower prices for venison, at least in real terms. This would bring venison within the reach of a wider group of consumers, but the profitability of this new industry would eventually be reduced.

References

Projections of meat production, demand and trade to 1985. Document CCP: ME 79/4. Rome, FAO, February 1979.

Farming the red deer. Rowett Research Institute and Hill Farming Organization, Edinburgh, 1974.

Grün- und Brachlandnutzung durch Damtiere. G. Reinken. Landwirtschaftskammer Rheinland, Bonn, 1977.

Heertenteelt. A.A.J. van der Leun, Instituut voor Veeteeltkundig Onderzoek Schoonoord, Zeist, Netherlands, 1978.

Follow-up to guidelines for international cooperation in the livestock and meat sector. Document CCP: ME 79/5, Rome, FAO, March 1979.

Concerning IUFRO and the sharing of knowledge

The International Union of Forestry Research Organizations (IUFRO) was founded in 1891-92 with the aim of rationalizing research techniques, standardizing systems of measurement and promoting international cooperation in forestry research. Today IUFRO has a membership of 10 000 scientists and 500 institutes from 85 countries. In addition to following its original aims, IUFRO represents an important level of scientific coordination undertaken by scientists themselves. It represents, therefore, not only the scientist's constant search for knowledge about life, but a sense of responsibility about the wise use of this knowledge: that it should not be used in isolation, but that it should be shared as much as possible. Mankind can only benefit from such a view and from such efforts.

This new UNASYLVA section for research news will appear from time to time and will carry news about IUFRO. It does not, however, replace or carry all the information of the IUFRO *News*, which is the organization's own newsletter.

First of all, we present the structure of IUFRO and the names of scientists in charge of various divisions and research groups. We do so not merely to support IUFRO, with which FAO has had a long association, but to give to our readers a useful and convenient tool for making international contacts as directly and personally as possible. Further information about IUFRO and its activities may be had by contacting the IUFRO in Vienna.

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The structure of IUFRO [1]

Division 1 - Forest Environment and Silviculture

CO-ORDINATOR: D. Mlinsek, Yugoslavia

DEPUTY: C.P. van Goor, Netherlands

Ecosystems (S1.01.00) (H. Mayer, Austria)
Virgin forests (01) (H. Mayer, Austria)

Silvicultural problems in mountain regions (02) (E. Ott, Switzerland; P. Piussi, Italy)

Physiological aspects of forest ecology (04) (W. Tranquillini, Austria)

Landscape ecology (05) (A.J. van der Poel, Netherlands)

Tropical and subtropical forest ecosystems (06) (E.F. Bruenig, FRG)

Natural parks, national parks and wilderness (07) (C. Berntsen, USA)

Site (S1.02.00) (S.P. Gessel, USA; R. Richard, Switzerland; M. Matsui, Japan)

Fertilization (01) (K.E. Rehfuess, FRG; W.L. Pritchett, USA)

Soil moisture regime and aeration of soils (02) (vacant)

International comparison of results of chemical analysis (03) (J. van den Burg, Netherlands; W.O. Binns, UK)

Influence of clearcutting on site (05) (D. Cole, USA)

Site classification (06) (D. Burger, Canada; K. Kreutzer, FRG)

Quantitative studies of site factors (07) (S.P. Gessel, USA; W. Kilian, Austria)

Foliar analysis and its interpretation (08) (J.B. Reemtsma, FRG)

Environmental influences (S1.03.00) (A. Baumgartner, FRG)

Atmospheric environment (01) (K. Perttu, Sweden; L.W. Gay, USA)

Forest hydrology (02) (H.M. Keller, Switzerland; J.A. Hayward, New Zealand)

Torrents, snow and avalanches (S1.04.00) (G. Kronfellener-Kraus, Austria)

Torrent erosion and control (01) (H. Ishibashi, Japan)

Snow and avalanches (02) (H. in der Gand, Switzerland)

[1] Groups of missing numbers have been cancelled.

Stand establishment, treatment and amelioration (S1.05.00) (H. Oswald, France; W.M. Stiell, Canada)
Afforestation of peatland and extremely wet soils (01) (L. Heikurainen, Finland)
Afforestation problems in arid and sub-arid regions (02) (S. Mestrović, Yugoslavia; M.A. Ogigirigi, Nigeria)
Treatment of young stands (03) (H.P. Lang, Austria; J. Huss, FRG)
Characterization of plan material (04) (H. Schmidt-Vogt, FRG)
Thinning experiments (05) (P. Abetz, FRG)
Multiple-use silviculture (06) (W. Doolittle, USA)
Use of herbicides (07) (A. Bonnemann, FRG; Christiane Volger, FRG)
Natural stand regeneration (08) (S. Purcelean, Romania; S. Skoklefald, Norway)
Improvement and conversion of degraded and coppice stands (09) (R. Giannini, Italy)
Monospecific coppice stands in short rotation (10) (J. Marquestaut, France)
Biological productivity (S1.06.00) (A. Vins, Czechoslovakia; C.L. Brown, USA)
Tropical silviculture (S1.07.00) (A. Pieters, Belgium; J.L.J. Groulez, France)
Structure of tropical rain-forests (04) (with S1.01.06) (vacant)
Natural regeneration of tropical rain-forests (05) (J.E.D. Fox, Australia)
Enrichment and conversion of tropical forests (06) (vacant)
Agroforestry (07) (vacant)
Silviculture of mangrove forests (08) (vacant)
Wildlife habitat management (S1.08.00) (R.C. Steele, UK; K. Eiberle, Switzerland; F.L. Bunnell, Canada)
Effects of forest management on wildlife habitats (01) (F.L. Bunnell, Canada)
Characterization and classification of wildlife habitats in forests (02) (J. Kikkawa, Australia)
Assessment of economic and social values of wildlife in forests (03) (W. Sommerlatte, FRG)
Forest fire research (S1.09.00) (P. Delabraze, France; Philpot, USA)
Land classification (P1.02.00) (with Division 4) (vacant)
Nursery problems (P1.04.00) (with Division 3) (C. Glerum, Canada; D.S.M. Donald, South Africa)
Arboriculture and urban forestry (P1.05.00) (with Divisions 2, 3, 4 and 6) (J.W. Andresen, Canada)

Division 2 - Forest Plants and Forest Protection

CO-ORDINATOR: R.Z. Callaham, USA

DEPUTIES: E. Donaubauer, Austria; H. Gerbold, USA; Hagman, Finland

Physiology (S2.01.00) (D.A. Rook, New Zealand; M. Giertych, Poland)
Reproductive processes (05) (S.L. Krugman, USA; O. Huhtinen, FRG; A. Dunberg, Sweden)
Seed problems (06) (M. Simak, Sweden; S.K. Kamra, Sweden; S. Asakawa, Japan)
World directory of tree physiology workers (08) (G.N. Brown, USA)
Xylem physiology (10) (P. Denne, UK; G.P. Berlyn, USA)
Shoot growth physiology (11) (A.C.H. Little, Canada; M.G.R. Cannell, UK, D. Lavender, USA)
Canopy processes (12) (T.A. Black, Canada; P.G. Jarvis, UK; E.D. Schulze, FRG)
Root physiology and symbiosis (13) (E. Hacskaylo, USA; A. Riedacker, France; R. van den Driessche, Canada)
Species, provenances, and gene resources (S2.02.00) (H. Barner, Denmark; R.H. Kemp, UK; J.F. Lacaze, France; V.I. Jermakov, USSR)
Dendrology (01) (B.T. Styles, UK; L.D. Pryor, Australia)
Conservation of gene resources (02) (L. Roche, UK; B.A. Ola-Adams, Nigeria)
Species monographs (03) (M. Vidakovic, Yugoslavia; D. Funk, USA)
Douglas-fir provenances (05) (Y. Birot, France; O. Sziklai, Canada)
Contorta pine provenances (06) (R. Lines, UK; J. Remroed, Sweden)
Larch provenances (07) (R. Schober, FRG; J. Sindelar, Czechoslovakia; S. Asada, Japan)
Tropical species provenances (08) (H. Keiding, Denmark; P.J. Wood, UK; W.H.G. Barrett, Argentina; S.P.K. Britwum, Ghana)
Eucalypt provenances (09) (L. Pederick, Australia; K. Diabate, Ivory Coast; M. Raggabi, Morocco)
Poplar provenances (10) (R. Koster, Netherlands; J. Jokela, USA; S.P. Ivannikov, USSR; S.Y. Shim, Republic of Korea)
Norway spruce provenances (11) (P. Krutzsch, Sweden; S. Kociecki, Poland)
Sitka spruce provenances (12) (J. O'Driscoll, Ireland; K. Illingworth, Canada)
Mediterranean conifer provenances (13) (R. Morandini, Italy; M. Arbez, France)
Abies provenances (14) (A.M. Fletcher, UK)
Breeding (S2.03.00) (J. Burley, UK; H.B. Kriechel, USA; S. Chiba, Japan)
Breeding tropical species (01) (D.G. Nikles, Australia; G.A.O. Ojo, Nigeria)
Breeding white pines (02) (H. Kriebel, USA; Emma de Vecchi-Pellati, Italy; H. Saho, Japan)
World directory of geneticists and tree breeders (04) (H. Nienstädt, USA)
Breeding Scots pine (05) (S. Bialobok, Poland; C. Matyas, Hungary)
Breeding nut species (06) (V. Benca, Romania; M. Jovanovic, Yugoslavia; D. Funk, USA)
Breeding poplars (07) (V. Steenackers, Belgium; E. Avanzo, Italy; L. Zsuffa, Canada; N.V. Starova, USSR)
Breeding Pinus radiata (09) (A.R. Griffin, Australia; R. Burdon, New Zealand; R.N. Delmastro, Chile)
Breeding Eucalyptus (10) (J. Davidson, Papua New Guinea; G. van Wyk, South Africa; A. Brune, Brazil; K. Eldridge, Australia)
Breeding Norway spruce (11) (J. Kleinschmit, FRG; V. Enescu, Romania)
Certifying genetic worth of forest reproductive materials (12) (R. Koster, Netherlands; H. Barner, Denmark)
Genetics (S2.04.00) (G. Namkoong, USA; C.J.A. Shellbourne, New Zealand)
Population and ecological genetics (01) (C. Franklin, USA)
Breeding theory (02) (A. Nanson, Belgium; M. Arbez, France)
Progeny testing (03) (J.F. Kraus, USA; M. Wilcox, New Zealand)
Biochemical genetics and cytogenetics (05) (P.T. Feret, USA; H.J. Muhs, FRG; L.C. Saylor, USA)
Genetic resistance to insects and diseases (S2.05.00) (B. Soeegaard, Denmark; R.F. Patton, USA)
Resistance of pines to blister rust (01) (G.I. McDonald, U.S.A.)
Resistance of elms to diseases and insects (H.M. Heybroek, Netherlands; D.T. Lester, USA)
Resistance of poplars to diseases (03) (M. Ridé, France)
Resistance of poplars to insects (04) (G.M. Arru, Italy)
Resistance of pines to Melampsora pinitorqua (05) (F. Moriondo, Italy; T. Kurkela, Finland)
Pathology (S2.06.00) (B.K. Bakshi, India; C.S. Hodges, USA)
Root- and butt-rot in conifers (01) (G. Wallis, Canada; I. Dimitri, FRG)
Canker diseases — Scleroderris (02) (J. Gremmen, Netherlands; D. Skilling, USA)
Biological control (03) (J. Rishbeth, UK; D.H. Marx, USA)
Needle diseases (04) (C.S. Millar, UK; G. Peterson, USA)
Mistletoes (05) (F. Hawksworth, USA)
Dutch elm-disease problem (06) (J.N. Gibbs, UK; J. Peacock, USA)
Phytophthora *and related diseases* (07) (F.D. Podger, Australia; D.H. Marx, USA)
World directory of forest pathologists and entomologists (08) (L.R. Anderson, USA; H.O. Batzer, USA)
Mycoplasma diseases of forest trees (09) (S.P. Raychaudhuri, India)
Rusts of pines (10) (Y.J. La, Republic of Korea; H.R. Powers, USA)
Diseases of Eucalyptus (11) (M.S. Reis, Brazil)
Pine diseases in the tropics (12) (I.A.S. Gibson, UK; M. Odeyinde, Nigeria)
Phytosanitary regulations and quarantines (13) (D.H. Phillips, UK)
Entomology (S2.07.00) (R. Stark, USA; A. Bakke, Norway; F. Kobayashi, Japan)
Cone and seed insects (01) (H.O. Yates, USA; D. Singh, Malaysia)
Integrated control of Hypsipyla *species* (02) (R.I. Gara, USA; G. Budowski, Costa Rica)
Integrated control of Hylobius *species* (03) (H.H. Eidmann, Sweden; J.A. Nord, USA)
Integrated control of Scolytid barkbeetles (05) (L. Safranyik, Canada; P. Carle, France)
Population dynamics of forest insects (06) (A.A. Berryman, USA; W. Baltensweiler, Switzerland)
Pine insects in the tropics (07) (H. Schumutzenhofer, Austria; A. Yamane, Japan)
Damage by vertebrates (S2.08.00) (R. Dzieciolovski, Poland; A. Myllymäki, Finland;

W.H. Lawrence, USA)
Air pollution (S2.09.00) (J. Materna, Czechoslovakia; T. Inoue, Japan; W. Knabe, FRG)
Air quality criteria and risks (03) (W. Knabe, FRG; S. Linzon, Canada)
Effects of acid precipitation (05) (L.D. Dochinger, USA; R. Horntvedt, Norway)
Management of forests under pollution stress (06) (K.F. Wentzel, FRG; V. Tesar, Czechoslovakia; E. Pelz, GDR; M. Solar, Yugoslavia)
Methodology of foliar analysis (07) (K. Stefan, Austria; H.G. Dässler, GDR; J.J. Jacobson, USA)
Physiological indicators of air pollution (08) (G. Halbwachs, Austria; H.J. Jäger, FRG; T. Keller, Switzerland)
Physiological basis of resistance (09) (S.J. Godzik, Poland; H.G. Dässler, GDR)
Methods of forest mensuration in diagnosis and evaluation (10) (J. Pollanschütz, Austria; J. von Platen, FRG)
Host parasite interrelationship (11) (Z. Sierpinski, Poland; E.B. Cowling, USA)
Resistant species and varieties (12) (F. Scholz, FRG; D. Karnosky, USA)
Indicator species and varieties (13) (A.C. Posthumus, Netherlands; A. Costonis, USA)
Pesticides (S2.11.00) (W. Lanz, FRG)
Interaction between site factors and destructive agents (P2.01.00) (with Division 1) (K. Shea, USA; G. Page, Canada; Y. Mashimo, Japan)
Productivity of plantation forestry with fast growing species (P2.02.00) (with Divisions 1, 3, 4 and 5) (A. van Laar, South Africa; H. do Amaral Mello, Brazil; J.H. Cayford, Canada)
Eucalypts (01) (R.N. Cromer, Australia)
Pines (02) (E. Shoulders, USA)
Impacts of destructive agents (P2.03.00) (D. Schvester, France; A. Yamane, Japan; G. Weste, Australia)

Division 3 - Forest operations and techniques

CO-ORDINATOR: M. Bol, Netherlands

DEPUTY: K. Putkisto, Finland

Harvesting and transports (S3.01.00) (T.C. Bjerkelund, Canada; S. Yamawaki, Japan)
Harvesting machines and methods under non-mountainous conditions (01) (P.O. Nilsson. Sweden; B.Y. Richardson, USA; R. Grammel, FRG)
Harvesting machines and methods in mountainous regions (02) (H.H. Lysons, USA; V. Staud, Czechoslovakia; G.V. Wellburn, Canada)
Long-distance transport of wood products (04) (K. Wibstad, Norway; A.E. Hakkarainen, Finland)
Forest roads (I. Herpay, Hungary; M. Kamiizaka, Japan)
Operational methods in the establishment and treatment of stands (S3.02.00) (S.E. Appelroth, Finland; G. Laryukhin, USSR; S. Okawara, Japan)
Stand establishment (01) (L. Riley, Canada; C.G.R. Chavase, New Zealand)
Stand treatment (02) (C.E. McGee, USA; P.O. Baeckstroem, Sweden)
Operational planning and control; work study (S3.04.00) (H.H. Höfle, FRG; S. Nilsson, Sweden)
Planning and control (01) (T.J. Corcoran, USA; W. Heij, Netherlands)
Work study; payment; labour productivity (02) (A. Whayman, UK; H.I. Winer, Canada)
Forest operations in the tropics (S3.05.00) (T. Haarlaa, Finland; W.A. Shoo, Tanzania)
Harvesting and wood utilization (P3.01.00) (with Division 5) (P. Hakkila, Finland; J.R. Erickson, USA; P. Dietz, FRG)
Ergonomics (P3.03.00) (T. Vik, Norway; J.H. van Loon, Netherlands; W. Fibiger, Poland)
Vibrations (01) (S.A. Axelsson, Sweden, J.E. Hansson, Sweden; Ohsato, Japan)
Psychosocial problems (02) (B. Gardell, Sweden; P.L. Cottell, Canada)
Accidents (03) (J. Wenel, Austria; B. Strehlke, FRG)
Ergonomics in the timber industry (04) (B. Ager, Sweden; C. Boye, Denmark)

Division 4 - Planning, Economics, Growth and yield, Management and policy

CO-ORDINATOR: R. Plochmann, FRG

DEPUTIES: D. Johnston, UK; J. Zivnuska, USA

Mensuration, growth and yield (S4.01.00) (J. Fries, Sweden; J. Pollanschütz, Austria; T.C. Honer, Canada)
Mensuration of forest biomass (01) (H. Madgewick, New Zealand; C. Grier, USA)
Estimation of increment (02) (K. Johann, Austria; D. Bruce, USA)
Design of experiments (03) (H.L. Wright, UK; J. Fries, Sweden)
Growth models for tree and stand simulation (04) (T.G. Honer, Canada; N. Decourt, France)
Instruments (05) (D. Bruce, USA; C. von Essen, Sweden; B. Hellrigl, Italy)
Forest resource inventory (S4.02.00) (T. Cunia, USA; K. Kuusela, Finland)
Resource data in tropical countries (01) (A.J. Nash, USA)
Resource data in temperate countries (02) (K. Kuusela, Finland)
Forest inventory on successive occasions (03) (P. Schmid, Switzerland; W.E. Frayer, USA)
Application of electronic data processing to forest inventory (04) (W. Schöpfer, FRG; I.E. Barnard, USA)
Forest management planning and managerial economics (S4.04.00) (R. Magin, FRG; I. Eraslan, Turkey; A. Lundgren, USA)
Inventory of stands (01) (J. Marschall, Austria; H. Sterba, Austria)
Stands, site types, and management targets (02) (A. Priesol, Czechoslovakia)
Management methods with respect to the function of forest (03) (F. Carcea, Romania)
Managerial economics and planning systems (04) (W.R. Leuschner, USA)
Economics at national and international level (S4.05.00) (vacant)
Evaluation of the contribution of forestry to economic development (01) (A.J. Grayson, UK; I. Holland, USA)
Forecasting of roundwood supply (02) (L. Lönnstedt, Sweden)
National income accounting (03) (L. Heikinheimo, Finland)
Forestry policy (S4.06.00) (P. Riihinen, Finland; A.J. Grayson, UK)
Effectiveness of policy measures as applied to small woodlands (01) (V.P. Järveläinen, Finland)
Effective policies for stimulating investment in forestry and forest industries in developing countries (02) (H.J. von Maydell, FRG; H. Gregersen, USA)
Forest taxation (03) (W. Kroth, FRG; E.T. Williams, USA)
Economic, technological and environmental aspects of wood substitution (P4.01.00) (with Division 5) (D.N. Quinney, USA; J.F. Saeman, USA)
Economics and harvesting of thinnings (P4.02.00) (with Divisions 1 and 3) (H. Kramer, FRG; C.J. Bredberg, Sweden; A. Berg, USA
Thinning and mechanization (01) (P.T. Brenoee, Denmark; C.M. Kerruish, Australia)
Economics of spacing and thinning (02) (A. Berg, USA; J. Ph. Schütz, Switzerland)
Economics of recreation on forestry and human environment (P4.03.00) (with Divisions 1 and 6) (E. Gundermann, FRG; H.F. Kaiser, USA)
Economics of afforestation and reforestation (P4.04.00) (with Divisions 1 and 3) (M. Keltikangas, Finland)
Steering systems (P4.07.00) (with Division 3) (D.I. Navon, USA; G. von Malmborg, Sweden)

Division 5 - Forest products

CO-ORDINATOR: W.E. Hillis, Australia

DEPUTY: R.W. Kennedy, Canada; J.G. Sunley, UK

Wood quality (S5.01.00) (P.R. Larson, USA; H. Polge, France)
Formation of wood (01) (J.M. Harris, New Zealand; R.K. Bamber, Australia)
Natural variations in wood quality (02) (J. Bauch, FRG; T. Higuchi, Japan)
Biological improvement of wood properties (04) (P.O. Olesen, Denmark)
Wood properties desired by end-users (05) (J.D. Brazier, UK; M. Chudnoff, USA)

Bark properties and utilization (06) (H.E. Wahlgren, USA; B. Lönnberg, Finland)
Wood engineering (S5.02.00) (J.G. Sunley, UK; B. Madsen, Canada)
Mechanical properties (01) (J.G. Sunley, UK)
Structural utilization (02) (J.G. Sunley, UK)
Time and moisture effects (O. Brynildsen, Norway)
Wood protection (S5.03.00) (M. Fougerousse, France; J.F. Levy, UK)
Protection of solid wood and wood-based materials (01) (M. Fougerousse, France)
Protection of wood in storage (03) (P. Nylinder, Sweden)
Performance of wood in fire (04) (I. Stanke, FRG)
Biodeterioration of wood (05) (J.F. Levy, UK)
Wood processing (S5.04.00) (R.A. Hann, USA; H. Bednar, Austria)
Slicing and veneer cutting (04) (A. Rivera, Venezuela)
Panel products (05) (E. Kes, South Africa)
Drying (06) (J.A. Kininmonth, New Zealand; A. Schneider, FRG)
Wood gluing (07) (R.H. Gillespie, USA; S. Chow, Canada)
Milling and machining (08) (G. Pahlitzsch, FRG; B.C. Klamecki, USA)
Properties and utilization of tropical woods (P5.01.00) (D. Noack, FRG; R.L. Youngs, USA; F. Tamolang, Philippines)
Characteristics and properties to be evaluated (02) (D. Noack, FRG)
Systems of information exchange (03) (J.M. Yavorsky, USA)
Collection and assembling of sources of information (04) (J. Morellet, France)
Industrial use of tropical timber (05) (R.L. Youngs, USA)
Energy from forest biomass (P5.03.00) (with Divisions 1, 2, 3, 4 and 6)
Production and utilization of bamboo and related species (P5.04.00) (with Divisions 1, 2, 3 and 4) (T. Higuchi, Japan)

Division 6 - General subjects

CO-ORDINATOR: Jean Pardé

DEPUTY: L. Strand, Norway

Forest landscape, recreation and tourism (S6.01.00) (H. Heytze, Netherlands; G. Moeller, USA)
Documentation and information (01) (N. Stout, USA; H. Köpp, FRG)
Landscape management and environment (02) (R. Zundel, FRG; B.R. Litton, USA; A.F. Mitchell, USA)
Planning methodologies (03) (G.H. Elsner, USA; A.A.H.C. van Onzenoort, Netherlands)
Social studies (04) (M.H. Orrom, UK; P. Brown, USA)
Statistical methods, mathematics, and computers (S6.02.00) (W.G. Warren, Canada; A. Roeder, FRG)
Information systems and terminology (S6.03.00) (S. Schrader, FRG; T.B. Yerke, USA)
Multilingual forestry thesaurus (01) (J. Bouchon, France; T.B. Yerke, USA)
Multilingual forestry terminology (02) (R.K. Winters, USA; J.I. de la Maza, Spain)
Technical information systems related to forestry (03) (S. Schrader, FRG; Mary B. O'Hara, USA)
Information retrieval for forest products (04) (A.B. Brauner, USA; H. Bednar, Austria)
Training of research workers in scientific methodology (S6.04.00) (H.C. Dawkins, UK)
Remote sensing (S6.05.00) (C.R. Heller, USA; G. Hildebrandt, FRG; D.A. Stellingwerf, Netherlands)
Management of forestry research (S6.06.00) (D.L. Bosman, South Africa; J.H. Ohman, USA)
History (S6.07.00) (M. Devèze, France; A. Schuler, Switzerland; H. Rubner, FRG)

XVIIth IUFRO World Congress announced for Kyoto in 1981

The International Union of Forestry Research Organizations (IUFRO) has announced that it will hold its XVIIth World Congress in Kyoto, Japan, from 6 to 19 September 1981.

A week of conferences and discussions is to be followed by post-congress tours to various parts of the country for the purpose of gaining an understanding of Japanese forestry as well as general conditions of the country.

Host of the Congress will be the Japanese IUFRO Congress Council, which is made up of representatives of Japanese forestry organizations, including the national Forestry Agency, federal and local forestry research institutes, universities, academic societies and several professional associations.

Kyoto, picturesque and ancient capital of Japan, is located about 500 kilometres from Tokyo, a three-hour journey by fast express train. The theme of the Congress is "Research today for tomorrow's forests". The address of the Congress is:

XVIIth IUFRO World Congress
Secretariat
PO Box 2
Ushiku, Ibaraki, 300-12
Japan

ENVIRONMENT

Afghanistan's efforts to manage wildlife and environment

Five wildlife sanctuaries have been created by the Government of Afghanistan. It represents a move of international importance since some of the species of birds and animals involved are migratory and others are near extinction in this part of the world. The selection and decision to have these sanctuaries did not happen overnight.

In the early 1970s the Government sought assistance from FAO and the World Wildlife Fund to examine the wildlife situation and advise on how best to manage environment and species. Dr. Roland Petocz of Alaska went to Afghanistan as consultant for both organizations during this period and was responsible for surveying and planning the new sanctuaries. With the institution of the sanctuaries the project has now gone into its second phase, which is to assist the Government in implementing management plans.

The project will train Afghans in wildlife conservation techniques and aims to set up pilot management programmes in two of the sanctuaries. The first of these areas is the saline lake of Ab-i-Estada, situated at an elevation of 2 000 metres in Ghaz-

ni province, about 250 kms from Kabul. This lake supports a breeding population of up to 10 000 Greater Flamingos (*Phoenicopterus ruber*), and the most urgent need is to protect this colony against human disturbance and especially egg collecting. The area is an important wintering area for wildfowl and is visited in spring and autumn by tens of thousands of ducks and waders migrating from the USSR to the Indian subcontinent. Among these migrants the entire western population of the Siberian Crane (*Grus Leucogeranus*), which numbers only about 40 individuals (out of a world population of only about 300), visits Ab-i-Estada in autumn and spring en route from their wintering grounds at the Ghana sanctuary in India. The World Wildlife Fund has provided $25 000 for warden accommodation and research facilities at the lake and construction began in April 1979.

The second area chosen for management is the Ajar Valley in the Hindu Kush, 200 kms northwest of Kabul. The valley was previously a royal hunting reserve but now along with the surrounding mountains it will be given more comprehensive protection. The area has dramatic landscapes: the valley floor is at 2 400 metres but nearby peaks reach over 4 000 metres. Domestic animals have been excluded for many years and the vegetation has not been subject to the same degree of overgrazing as much of Afghanistan's rangelands. There is a healthy population of ibex (*Capra ibex*) and on a recent visit in mid-winter I saw several hundred forced by snow to descend to the lower slopes of the mountains. A thicket of *Salix* sp. on the valley floor contains the only wild population of Bactrian deer (*Cervus elephas bactrianus*) outside the USSR (a few may still exist on the Afghan side of the River Amu Darya). The herd is derived from two animals introduced in 1953 and now numbers 42; they are readily seen by visitors. A herd of feral yak lives in the sanctuary but unfortunately their numbers have been much reduced by poaching. I only saw 26 on a recent visit where 70 were recorded in 1978.

The aim of management of the Ajar Valley will be to provide facilities and information for visitors and to set up an ecological monitoring programme to follow trends in the populations of large mammals and evaluate their interaction with the vegetation. The study of the vegetation could provide information applicable to the overexploited rangeland of the rest of Afghanistan. If wild animal populations build up to a level where they overexploit the vegetation then the scientific value of the sanctuary would be diminished. A tourist hunting programme is therefore being proposed so as to maintain populations within the carrying capacity of the area. The ibex provide fine trophies and considerable revenue will derive from the sale of permits.

Of the three remaining sanctuaries, two are wetland areas rich in waterfowl. One of these, Dashte Newar, is about 100 km west of Ab-i-Estada and is notable as being, at an elevation of 3 000 metres, the highest breeding place of Greater Flamingos in the world. Management policy will be similar to that for Ab-i-Estada and here also WWF are providing funds for warden and research facilities. The other area is a shallow lake in the suburbs of Kabul where a remarkable variety of birds can be seen. The lake has considerable potential for conservation education activities and provides a valuable recreational area for the people of the capital.

The final area, in absolute contrast, lies at 5 000 metres and above in the Pamir mountains in the Wakhan Corridor. It is the home of the "Marco Polo" sheep (*Ovis ammon poli*), and the Siberian ibex (*Capra ibex sibericus*). A rugged and innaccessible area, it has the potential to be an outstanding national park. At present the Afghan Tourist Organization organizes hunting expeditions for overseas visitors. A permit for a "Marco Polo" sheep costs US$12 000 and only 16 are issued each year.

The establishment of these five sanctuaries is a valuable start in the struggle to conserve wildlife and wild places in Afghanistan. The next stage will be to conduct an inventory of wildlife resources as a basis for a national strategy for conservation. The long-term aim of this strategy will be to conserve not only outstanding or unique areas but also representative examples of all the ecosystems of the country. It will also aim at producing greater environmental awareness among the people in the hope that conservation will be a factor in development planning.

J.A. Sayer
(Team Leader and Wildlife Ecologist, Wildlife Management Project, Kabul)

Panama declares national park in Canal Zone

Panamanian President Aristides Royo recently declared the creation of the Parque Nacional de la Libertad, an area of 1 011.5 hectares which includes one of the world's most accessible and best studied rain forests. The park, which contains the habitat of many rare and endangered species, is also important from an economic perspective in that it will help protect against siltation of the canal. Conservationists applauded the President's action as a demonstration of Panama's commitment to come to grips with the problems of deforestation and soil erosion which threaten the Canal Zone watershed. As a protected area, the park will be part of a project which will take into account the ecology of the total watershed and seek to institute suitable land-use practices.

Environmental institute in Africa

The newly founded Institute of Environmental Studies in Khartoum, Sudan, will be especially concerned with research into the most serious environmental problems of the continent. The spread of desertification is one of these. The Institute is affiliated with the Faculty of Science of Khartoum University.

An economic view of pastoralism that is not unkind

The economics of pastoralism: a case study of sub-Saharan Africa, by Z.A. Konezacki. Frank Cass and Co. Ltd., London, 1978. 185 p., £9.50.

Pastoralism has been little studied by economists; most of the literature on the subject deals with anthropology, natural science and the environment. Konezacki's book then, with its case studies of sub-Saharan pastoral economics is a welcome contribution.

Pastoralism, says the author, is an economic activity in which man and herds of domestic animals live in a symbiotic relationship. It does not include large-scale commercial cattle ranching or the raising of small numbers of livestock on farm lands. Rather, in pastoralism, herding is the main form of subsistence, though it may be combined with crop production. There are several forms of pastoralism: nomadic, semi-nomadic, and transhumant (seasonal movement), for example — all discussed by Konezacki.

The book concentrates on rain-deficit zones (less than 500 mm annual rainfall) and in particular on the least developed countries in these zones. The grazing potential of the arid zones, according to Konezacki, is being either misused, for lack of a scientific approach, or not utilized owing to poor accessibility. And the importance of these facts, he points out, is that in the absence of alternatives for local employment, pastoralism provides most people in these areas with their livelihood.

Some of the features of sub-Saharan pastoralism treated in the book are (*i*) the harsh ecological conditions and consequent limited capacity of the land; (*ii*) the insignificant proportion of land under crops, most being under pastures, meadows, forests; (*iii*) livestock raising, as the main source of livelihood and as the basis of the economy; (*iv*) survival of age-old pastoral practices, such as maintaining large herds, and common ownership of grazing lands, which tend to become overgrazed; and (*v*) the generally insignificant amount of trade in livestock, pastoral economies being largely self-sufficient.

Konezacki stresses that the main problem facing pastoralists in the arid zones is adjustment of stock numbers to natural feed sources. Therefore, he says, there is need for the establishment of a stable equilibrium, both ecologically and economically, between human and livestock populations and the land. There is an interesting contrast drawn between a model of an "idealized" pastoral society — containing the basic conditions for achievement of equilibrium — and a "real-world" pastoral society. If the equilibrium necessary for the survival of pastoralism as a way of life and a method of production is to be achieved, Konezacki concludes, outside intervention is inevitable.

The book also deals with scientific management of the usually overused pastoral lands and with the problems of increasing herd sizes.

Konezacki has devoted one chapter to a case study of Somalia, concentrating on the economic aspects of nomadic pastoralism. Nearly two thirds of the country's population are nomads and they naturally have considerable impact on the economy. Economic planning from 1950 and the factors which led to a dramatic growth of livestock exports are reviewed. There is also a discussion of government action taken to deal with the recent drought.

There is an assessment of the drought in the Sahelian countries — Mauritania, Senegal, Mali, Upper Volta, Niger, Chad — which has attracted world attention. Particular attention is paid to the man-made interventions which permitted or caused the occurrence of widespread hunger and enormous losses in animal population, such as control of disease by vaccination and immunization leading to overstocking, extending watering facilities for animals through deep well-boring programmes resulting in the overgrazing of pastures within an increasingly widening area around them. The author rightly questions not the intentions which motivated these programmes, but the planners' understanding of the problems they were attempting to solve. There is a critical analysis of proposals offered, such as enforced settlement, to solve the fundamental problems of the regions.

The livestock sector on Botswana, whose population depends greatly on livestock raising, is also treated by Konezacki. He discusses the rapid growth of the livestock population and the consequent degradation of grazing lands, and he includes information on the Government's efforts to achieve scientifically controlled range management.

The book concludes with a review of approaches to the solution of the

problems of sub-Saharan pastoralism. Konezacki points out that a scrutiny of modern planning methods applied to pastoral sectors reveals persistent use of measures that unintentionally encourage animal hoarding. And the planners, he says, have neglected to implement measures that would improve range management, marketing, and land-tenure systems. Konezacki also contends that government attempts to resettle nomads produced disappointing results, and he adds that the money spent on these schemes could have been invested instead in improvement of pastoral methods of production.

Konezacki also proposes a series of pastoral reforms. They include (*a*) introduction of an insurance scheme for pastoral nomads which would protect against natural calamities; (*b*) reform of existing land-tenure systems; (*c*) implementation of policies to provide alternative possibilities for employment; (*d*) formation of farming cooperatives for small livestock owners; and (*e*) restriction of herd size. In short, Konezacki says, what is required is neither the maintenance nor the complete liquidation of the *status quo*, but its modification.

P. ARGAL

Man's hand on nature

Conservation and agriculture, edited by J.G. Hawkes. Gerald Duckworth and Co., London, 1978. 284 p., £14 (in UK).

This book concerns man's interaction with the natural environment and sets out ways to obtain a balance between environmental conservation and land use. The contributors are from a number of disciplines, including archaeology, ecology, forestry and geography.

The history of agricultural development is treated by several authors. G.W. Dimbleby discusses within a broad temporal and spatial context some of the major changes effected in the natural environment by the evolution of the forest from a place for hunting and gathering to a place for raising animals and crops. H. Thorpe presents a case study of interaction between the land and the people and traces environmental changes over three millennia within the shire of Warwick in the UK. D. Brothwell examines the influence of human populations on the survival, biology and health of many animal species, particularly those that have food value.

One section of the book deals with the threat to world genetic resources and ways to preserve them as essential materials for developing improved strains of domesticated plants and animals. The point of view here is that use or misuse of all resources, including genetic resources, is determined ultimately by political decisions; therefore, according to the authors, political action as well as scientific research is needed to protect genetic resources. Erna Bennett, a geneticist with the FAO Plants Division, discusses threats to crop-plant genetic resources and the need to conserve them. She observes that of the many species of plants only relatively few have been used by man and of these barely a score constitute man's major crops. Dr. O. Frankel's paper contains an excellent account of food crop genetic resources. He discusses exploration and conservation of genetic resources and their systematic evaluation as an essential for utilization, and includes descriptive documentation of collected material and information on the education and training of staff. J.L. Henson, dealing with rare farm animals in the UK, notes that some useful breeds have been lost and others are on the verge of extinction unless serious attempts are made to preserve them.

Focusing on forestry and forest resources, Dr. K.F.S. King, head of the International Council for Research in Agro-Forestry, Nairobi, and former Assistant Director-General in charge of Forestry at FAO, speaks of both the economic and environmental contributions of forests to development, particularly in third world countries. He stresses that it is possible to manage forests for both economic development and protective and recreational service. He points out that forest exploitation and management may, however, threaten some species and eventually alter the pattern of competition in the forests. Therefore, King says, efforts should be made to preserve endangered species and to maintain representative areas of plant formations and ecosystems throughout the world.

In discussing the present genetic resources of forest trees, R.H. Kemp and J. Burley report that relatively few species are in danger of extinction, a point of view many conservationists may dispute. They express concern, however, about extensive destruction of forests in many parts of the world, particularly in tropical regions, which may lead to the extinction of species of unknown value. The authors believe that of the species already known to be of value for use in highly productive plantation forestry, few have been explored adequately and that there is danger that valuable provenances of such species may disappear even before they can be evaluated and utilized.

The book also contains a section on food production in India. Here M.S. Gill gives a lucid accout of the success achieved in increasing wheat production in the irrigated areas of northwest India (Punjab). J.C. Harris reports on the progress made in increasing rice production in the southern state of Tamil Nadu, and J.B. Hutchinson evaluates the Indian achievement in food production as a whole.

The balance between food production and conservation is also examined in this book. M.W. Holdgate discusses this balance as a component of land management. A decision on the correct use of a land area, he says, includes consideration of its instrinsic environmental properties, including the socio-economic conditions of the communities living there.

Very well produced, this volume will be of value of those who have responsibilities to protect the environment as well as to lay readers.

P. ARGAL

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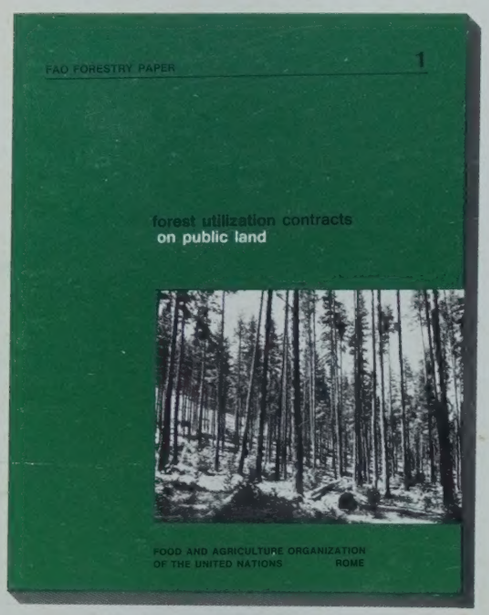
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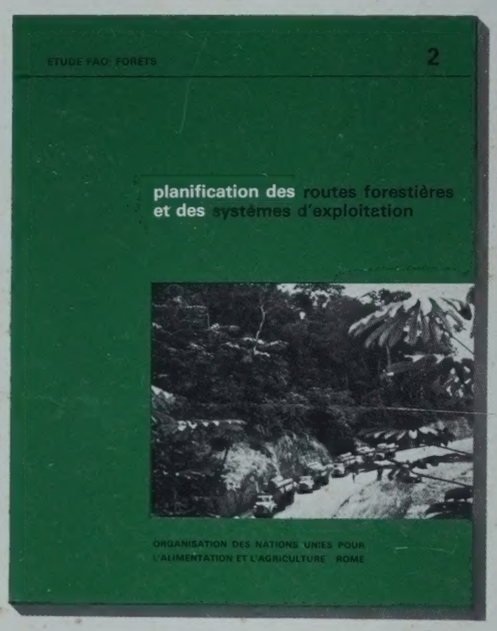
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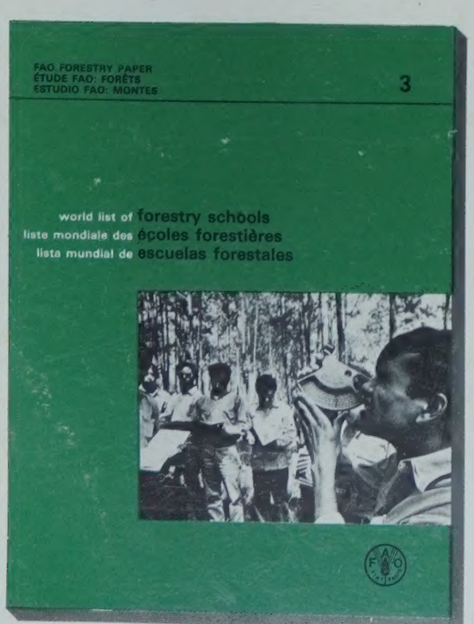
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4. Specifications for the identity and purity of thickening agents, anticaking agents, antimicrobials, antioxidants and emulsifiers, 1978 (E*)
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